ABSTRACT

EFFECT OF CERTAIN PACKING FACTORS
ON FROZEN STRAWBERRIES AND RASPBERRIES
IN MICHIGAN AND OREGON

by Clifford Elroy Samuels

This investigation was made to provide more scientific information on the effect of certain packing factors on frozen sliced strawberries and frozen red raspberries. Berries from both Michigan and Oregon were used.

Data were obtained to show the effect of the following treatments on drained weights and soluble solids: (1) strength and amount of packing media, (2) size of container, and (3) partial replacement of sugar sirup with corn sirup. Additional data were obtained in Michigan with respect to: (4) the effect of thawing frozen sliced strawberries and frozen red raspberries by means of moving water and moving air, and (5) the effect of extended thaw-time in moving water on frozen sliced strawberries.

The results indicated that a loss of drained weights and soluble solids occurred in samples packed in a water medium and those in which there was no packing medium. In sirup and dry sugar samples there was a gain in drained weights and soluble solids. There was no difference in drained weights between 50° Brix and 60° Brix packs. With the exception of Michigan sliced strawberries, higher drained weights were obtained when maximum amounts of packing medium were used.

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Increasing the size of container resulted in the decrease of drained weight ratios and the increase of soluble solids in the thawed product (total blended mixture) and drained berries.

There was no difference in drained weights or soluble solids between sucrose sirup packs and sucrose corn sirup packs.

Drained weights were higher and soluble solids were lower when frozen sliced strawberries were thawed by means of moving water. There was no difference between thawing treatments on the drained weights or soluble solids of frozen red raspberries.

Drained weights of frozen sliced strawberries were lower when thaw-time was extended two hours with no additional decrease at the four hour level; soluble solids were unchanged at two hours and higher at the four hour level.

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Much credit is due my wife, Emily, who not only helped throughout the experiment, but was my constant source of strength and inspiration. Her vast patience and constant encouragement have been greatly appreciated.

DEDICATION

This thesis is dedicated to my father and mother,

Mr. and Mrs. Henry C. Samuels.

TABLE OF CONTENTS

EFFECT OF CERTAIN PACKING FACTORS ON FROZEN STRAWBERRIES AND RASPBERRIES IN MICHIGAN AND OREGON

INTRODUCTION

The frozen food industry is a comparatively young industry and one which has experienced a rapid growth. In order to insure continued growth and in order to improve the quality of the frozen product, there is a great need for the development of definitions and objective measures of quality. Despite the fact that many scientists have done research on frozen foods, more scientific data must be available before the frozen food industry, the Production and Marketing Administration, and the Federal Food and Drug Administration can establish objective measurements to aid in indicating quality. Therefore, this investigation was made to provide more scientific information on frozen sliced strawberries and frozen red raspberries.

Many able scientists have made careful studies of frozen foods. Some began their studies shortly after the turn of the century. In 1904, Fulton began work on frozen pie-fruits, and the freezing of "cold pack" strawberries took place in the Northwest as early as 1908. But regardless of these early attempts, it might be said that the quick freezing industry for retail trade, as we know it today, had its official birth about 1923 (30).

By the end of 1940 there was evidence of tremendous growth. An industry census showed that there were 2,641 wage earners in the frozen

food industry with annual wages of $1.5 million. In March 1941, there were between 12,000 and 15,000 frozen food cabinets in retail stores.

By 1958, the industry census reported that there were over 300,000 wage earners and that the investment in the industry was over $5 billion. At the time of the census there were over 375,000 stores with frozen food cabinets (30). These figures clearly indicate the rapid growth of the industry. Frozen foods are no longer considered novelty or luxury items but are regarded as economical and convenient staples.

During the earlier years of growth the controversy raged as to whether standards should be adopted for frozen foods. At the present time, Federal Food and Drug Administration standards have not been adopted.

A standard is defined as that which is set up and established by authority as a rule for the measure of quantity, weight, extent, value or quality. Growth of the industry has been so rapid and general, both geographically and in the variety and volume of products packed, that each section has proceeded largely according to its own ideas of production procedure, quality and packaging. Therefore, the frozen food industry needs standards for their products and, in the main, desires them, but data which are suitable for presentation as evidence in aiding and establishing fair and reasonable standards are still lacking in many cases. At the present time the United States grade standards of the Production and Marketing Administration are dependent upon the observations and judgment of trained inspectors. The Federal Food and Drug Administration published proposed frozen food standards in the Federal Register of October 1950.

Follow up work has been published in the Journal of the Association of Official Agricultural Chemists in 1953, 1954, and 1955 by the Federal Food and Drug Administration. These standards have not been put into effect, which further indicates that additional data are necessary before the Federal Food and Drug Administration can actually promulgate the standards of quality which will be enforced.

It must be emphasized that establishment of standards without sufficient data and adequate knowledge of the processing methods necessary is extremely dangerous. For instance, in the November 1946 issue of "Frosted Food Field" there appeared an article about the 32nd National Conference on Weights and Measures sponsored by the United States Bureau of Standards. According to this article, the Committee on Methods of Sale of Commodities had submitted a report, adopted by conference delegates, part of which reads: "Instances are cited where, for instance, packers of frozen berries have by adding some sugar to water, taken the stand that they have created a sirup and, therefore, an edible food which they are allowed to declare in conjunction with the solids in the package. It needs no great stretch of the imagination to see how this will work out if the practice is allowed to continue in the frozen food industry. It is the belief and recommendation of the committee that frozen foods should be marked with the drained weight of the commodity entailed, and that any subsequent adding of moisture be left to the consumer."

From the above quotation it is obvious that the committee which formulated these recommendations had little knowledge of the processing methods necessary for the good keeping qualities of frozen fruit.

Evidently the committee expected that a housewife could take defrosted, dry packed whole berries, add sweetened water and miraculously produce a colorful, firm, plump and delicious berry dessert. If the procedure they suggested were carried out, she would serve a soggy, faded, tasteless dish and very likely refuse to purchase any other frozen food product.

Standards should be promulgated with three points in mind: (1) they must protect the consumer, (2) they must protect the packer, and (3) they must be such that the industry can meet them when the best procedures are used to process the best raw materials available. The industry knows that the consumer should be protected from poor quality food, and it also realizes that, if the consumer is not fully satisfied with frozen food products, the industry will be the first to suffer. Of equal importance, however, is the fact that when standards are applied to the industry for the benefit of the consumer these standards should be of such nature that they do not impose an undue hardship upon the industry.

This investigation was made to provide more scientific information on frozen sliced strawberries and frozen red raspberries. The Premier and Northwest varieties of strawberries were used in Michigan (1955) and Oregon (1956), respectively. The Taylor and Willamette varieties of red raspberries were used in Michigan (1954) and Oregon (1956), respectively.

Data were obtained in Michigan and Oregon to show the effects of certain packing factors on frozen sliced strawberries and frozen red

raspberries. These data showed the effect of the following treatments on drained weights and soluble solids: (1) strength and amount of packing media, (2) size of container, and (3) partial replacement of sugar sirup with corn sirup.

Additional data were obtained in Michigan with respect to: (1) the effect of thawing frozen sliced strawberries and frozen red raspberries by means of moving water and moving air, and (2) the effect of extended thaw-time in moving water on frozen sliced strawberries.

REVIEW OF LITERATURE

In canned fruits the sugar content of fruit and sirup is about equal, as cooking during processing makes the tissues permeable to the sirup and the sugar therefore penetrates readily and uniformly. However, Goodbrod (9), Perry and Cruess (20) report that in the freezing of fresh fruits one of the problems encountered is that of uneven distribution of the sugar between the fruit and the sirup.

Guadagni (11) reported that very slight variations in fruit-to-sugar ratio may influence judges who are sensitive to differences in sweetness. When it is considered that biological material is not uniform and that individuals differ from each other and are inconsistent with themselves from time to time, it is conceivable that there would, due to these variations, be considerable fluctuation. Therefore, objective measurements are greatly desired and needed. Lawler (17) also indicated that objective tests for frozen food quality are needed.

Robinson, Lee, Slate and Pederson (21) reported that their strawberries averaged 6.98 percent soluble solids for 311 variaties tested in 1945. Eighty-seven percent of the values fell between 5.1 and 8.0 percent. The average for 1946 at the same location in the state of New York was 8.84 percent, which was not a significant difference. These varieties were tested by using a fruit to sugar ratio of four to one.

Sistrunk and Cain (22) studied some of the factors affecting the suitability of berries for processing. Their data were based upon many experimental and commercial varieties grown at the Oregon

Agricultural Experiment Station farm, Corvallis. They found that variety, maturity and weather conditions appear to be the main factors involved in the differences in their objective data. The soluble solids and total solids of strawberries and red raspberries were slightly lower in 1958 than in 1957. This was believed to be due largely to the rainy weather during the harvesting period. Near the end of the season, however, the total and soluble solids values increased as drier weather prevailed.

The range of values for fresh strawberries for 1958 were from 6.2 to 11.6, with an average of 8.4 percent soluble solids on 22 samples. These gave an average of 26.3 percent soluble solids after packing with four parts of fruit to one part of dry sugar. The range of values for fresh red raspberries for 1958 were from 6.5 to 13.0, with an average of 8.8 percent soluble solids on 27 samples. These gave an average of 20.5 percent soluble solids after packing with 40° Brix sirup. Ten ounces of berries were used to five ounces of sirup.

Talburt, Leinbach, Brekke and McHenry (24) analyzed commercial samples of frozen strawberries for total acidity, total sugar, total solids, and soluble solids. It was thought that one or more of these analyses would provide a reliable index for determining constancy of the ratio of fruit to packing medium for the various types of equipment.

The analytical data, particularly total solids and degrees Brix obtained in these experiments, were stated to be good indexes of constancy of the ratio of fruit to packing medium. Since the fruit and packing medium have not come to equilibrium in composition at

time of filling, variations in ratio of fruit to medium during filling of successive containers will cause corresponding changes in total solids, degrees Brix, and sugar and acid contents of the product.

Data from these analyses of commercial samples showed significant differences in regard to constancy of ratio of fruit to sweetener or packing medium. It was found that there were gross variations in the composition, particularly in sugar content, between various samples regardless of the type of equipment used. These ranged from 16.0° to 24.7° Brix and 21.1° to 32.3° Brix for the sirup- and dry-sugar packs, respectively. Variations in composition of raw material and processing variables together were given as the likely explanation for the variability in composition.

Fallscheer and Osborn (5) reported that, in work on frozen strawberries and red raspberries, some difficulty was encountered in obtaining satisfactory collaborative results for drained weights.

Factors Affecting Drained Weights

Packing Media. Joslyn and Marsh (16) reported that weight losses in general varied with the kind and character of fruit. They were greatest in water and least in sirups of certain concentrations. The loss in weight, as a result of the freezing and thawing, did not vary in a regular manner with the concentration of sirup, as would be expected. There was no definite relation between loss in weight and concentration of sirup as would be the case if osmotic action alone had been responsible for the loss in weight.

The average loss in weight increased with increase in concentration of the sirup, being greater in 60° and in 40° Balling sirup than in 25° sirup. They believed that the loss in weight that occurs upon thawing is due not only to water extracted by the osmotic action of the sugar or sirup but also to loss of juice that exudes as a result of injury to the tissues on freezing.

The loss in weight of apricots decreased with increase in the ratio of fruit to added cane sugar, but the results for Banner strawberries were rather variable. The substitution of cerelose for cane sugar increased the loss in weight to some extent. The substitution of invert sugar testing 76.3° Balling decreased the loss in weight. However, in these tests there was no direct relation between the ratio of fruit to sugar and the loss in weight.

The data reported by Wiegant (27) indicate that in some instances the loss in weight of berries frozen with sugar increased as the ratio of fruit to sugar decreased, and in others there was no continuous and regular increase.

Perry and Cruess (20) showed that strawberries, packed four parts of berries to one part of sugar and frozen, lost much more weight than those packed in 40° Brix sirup and, in the dry sugar pack, the sugar penetration was not much greater.

Joslyn (15) stated that it is clearly evident that the loss in weight after freezing is less in the 40° Brix sirup pack than in the sugar pack, and that this loss increases with an increase in sugar concentration or with an increase in the ratio of sugar to fruit.

Bedford (3) reported higher drained weights on strawberries and red raspberries with the use of sirups.

Aref, Sidwell and Litwiller (1), Bockian and Aref (4) found that whole strawberries frozen in ten pound friction-top cans were more influenced by the ratio than by the kind of sweetener added to the fruit prior to freezing. The nine to one ratio resulted in the highest drained weights, and the four to one ratio resulted in the lowest. They thawed the frozen whole berries at about 72° F. exactly 24 hours. Then the berries were drained for three minutes on an eight-mesh wire screen, which was eighteen inches in diameter. Both the drained berries and the drip were weighed separately, their combined weights considered as the total weight, and the percentage drained weight calculated.

<u>Delay of Freezing</u>. Joslyn and Marsh (16) made a calculation of the amount of sugar absorbed by strawberries. It showed that preliminary storage at 32° F. before freezing practically doubled the absorption of sugar by the berries. Owing to losses due to absorption by the container and evaporation in storage, which can be corrected for only approximately, the absorption of sugar calculated by a "sugar balance" did not agree exactly with that calculated by a "water balance."

There was more variation in sugar absorbed than in water withdrawn. The water withdrawn increased somewhat, but not markedly and not regularly, with increases in concentration of sugar or sirup. The loss in weight found was not equal to that calculated from the

difference between water withdrawn and sugar absorbed, although it was of the same order of magnitude. They postulated that this may be due to certain inaccuracies in results, such as failing to correct completely for evaporation and carton absorption losses, or to errors in the postulated mechanisms. They thought that the latter was probably the case.

Perry and Cruess (20) stated that delay of freezing can have a definite effect on the drained weight.

Wiegand and Wilder (28) showed that delaying the freezing of packages does not result in higher or lower drained weights but does effect their variability. The drained weights varied less when packages were delayed after processing before freezing than when frozen immediately. Variation in the drained weight of identical packages was much larger than the variation of the sirup cut-out.

Wiegand and Wilder (29) found that there is very little effect on the drained weight by delaying packages for one-half, one and two hours before freezing. It was discovered that the drained weights from the packages that were not put into the freezer immediately after packing varied less from package to package than those frozen immediately. In other words, when the packed fruits were held back from going into the freezer immediately, it tended to even out the differences or variations between package drained weights.

<u>Storage Temperature</u>. Joslyn and Marsh (16) indicated that the osmotic action of the sirup plays an important role in the extraction of water from the fruit when stored at room temperature. Fruits

packed in water or dilute sirup generally gain weight while those packed in concentrated sirups lose weight.

Guadagni, Nimmo and Jansen (10) indicated that even though marked changes in solids distribution occurred in the thawed samples, no significant drained weight changes could be demonstrated during storage of frozen strawberries at temperatures of 0° to 30° F.

Guadagni, Nimmo and Jansen (12) determined drained weights by thawing the samples at room temperature in the draft of an electric fan for two hours, and then draining the samples on a screen of eight-mesh wire for two minutes.

The samples of red raspberries were packed into twelve ounce composite cartons in the ratio of three parts berries to one part of 50 percent sucrose sirup. After packing, the samples were frozen in air-blast freezers at 0° to -20° F.

The drained weight of the raspberries gradually decreased during storage at 20° F. to the extent of approximately 10 percent. At lower temperatures, no consistent trends of decreasing drained weights were observed. At higher temperatures the magnitude of the changes was approximately the same, but they occurred much more rapidly.

Guadagni and Nimmo (13) pointed out that, with retail packages of frozen strawberries and red raspberries, no significant differences could be demonstrated in the drained weights of samples held at the fluctuating cycles and mean steady temperatures. This might be due to the extensive variations in fruit-to-liquid packing media; but since there was little or no difference in drained weights during

storage at temperatures of 0° to 30° F., it is unlikely that fluctuation significantly affects this measurement.

Thawing Method. Woodruff (31) reported that the loss of juice from a frozen fruit on thawing is not due to the rupturing of the cell wall, but it is due to the denaturation of the protein within the cell. This has not been substantiated by recent studies.

Joslyn and Marsh (16) reported that a decrease in the weight of frozen fruit occurs during and after thawing. They believe this decrease is due to water separating as ice during freezing and not reabsorbed during thawing, to leakage of fluids through tissues injured by freezing, and to osmotic action of the sugar or sirup. It does not depend entirely upon tissue disorganization, since it is offset in part by absorption of sugar in the case of sugar and sirup-pack fruits, but it depends to a large extent upon the handling of the product during thawing and draining. It is difficult to remove all of the added and exuded juice, sirup, or water from the product by draining after thawing, although data so obtained are comparable.

In general, the losses reported varied with the kind and character of fruit. They were greatest in water and least in sirups of certain concentrations. The loss in weight, as a result of the freezing and thawing, did not vary in a regular manner with the concentration of sirup, as would be expected. There was no definite relation between loss in weight and concentration of sirup as would be the case if osmotic action alone had been responsible for the loss in weight. These results are similar to those reported by Wiegand (27) for berries.

Fallscheer and Osborn (5) stated that drained weights of frozen fruits show promise as a rapid means of calculating fruit content.

Fallscheer (6) recommended that drained weights be used as a rapid sorting method for estimating the proportion of fruit in frozen fruit packs. However, he recommended that the method be used as stated by Osborn and Hatmaker (19). The packages should be allowed to thaw in their original containers, without disturbing the contents before draining. This was found more reliable than the method by Fallscheer and Osborn (5) in which the frozen sample was removed from its container and placed in a pliable bag of convenient size.

The three above authors and Hirzel (14) felt that, if drained weights are to be used for standards, a standard thawing method should be adopted. They recommended that the samples be thawed in a 68-70° F. water bath until the center of the sample reaches this temperature. The water should be agitated while the samples are being defrosted.

Factors Affecting Soluble Solids

Packing Media. Joslyn (15) reports that a 50° Brix sirup was the minimum concentration necessary for color retention in strawberries.

According to Fieger, Dubois and Kalgereas (8), a better frozen strawberry pack was produced by the addition of sugar to Klondike strawberries instead of sirup. The use of sirup resulted in floating of the berries and less uniform absorption of the sugar solution. Whole berries absorbed less sugar than slices. The panel rated

sliced fruit highest when a four to one or five to one fruit-sugar ratio was used.

Bartlett and Hard (2) stated that red raspberries packed in corn sirup were judged equal to the control in portions of replacement sirup up to 75 percent.

Strohmaier and Pen (23) indicated that the best general method of preparing frozen strawberries for evaluating varieties thus far tested was slicing and mixing with dry sugar in a four or five to one ratio. A 40° Brix pack was made to get an actual ratio of fruit to sugar of five to one, having the fruit covered with sirup and a net weight of one pound. Their California varieties of strawberries tested from 7.4 to 10.3 percent soluble solids.

Fallscheer and Osborn (5) indicated that, when the packing medium is dry sugar, a soluble solids reading on the refractometer will give a rapid and quite accurate means of calculating the fruit content. After the fruit to packing medium ratio for sirup-packed fruit has been calculated, the soluble solids figure gives a convenient means of calculating sirup strength.

Osborn and Hatmaker (19) made a study of samples collected over a period of years from the areas of production in the United States and came up with a national average of 8.0 percent soluble solids for fresh strawberries and 10.5 percent for red raspberries.

Delay of Freezing. Joslyn and Marsh (16) made a calculation of the amount of sugar absorbed by strawberries. It showed that preliminary storage at 32° F. before freezing practically doubled the

absorption of sugar by the berries. Owing to losses due to absorption by the container and evaporation in storage, which can be corrected for only approximately, the absorption of sugar calculated by a "sugar balance" did not agree exactly with that calculated by a "water balance."

There was more variation in sugar absorbed than in water withdrawn. The water withdrawn increased somewhat, but not markedly and not regularly, with increases in concentration of sugar or sirup.

Fieger, Dubois and Kalgereas (8) reported that Klondike strawberries were found to absorb more sugar when frozen immediately than they did after a one-hour holding period prior to freezing. Any delay in freezing after the addition of dry sugar resulted in poorer quality when compared to the quality of strawberries that were frozen immediately.

Storage Temperature. Wiegand and Wilder (28) indicated that there is generally no significant difference in the cut-out values between four and twelve weeks storage at 0^{o} F. of frozen fruits. The data from their investigation pointed out that some combinations of in-going fruit and sirup result in a higher drained weight. It was noticed that the sirup cut-out is influenced less than the drained weight by differences in fruit. However, a given sirup cut-out was not a reliable index of in-going fruit weight.

Guadagni, Nimmo and Jansen (10) made a study of retail packages of frozen strawberries and found that the ratio of soluble solids between drained fruit and sirup indicated no significant change during

storage at temperatures of 10° F. or lower. When the temperature was raised to 20° F. there was a slight increase in solids ratio until an apparent equilibrium value was reached. At 25° F., a very gradual increase in solids ratio occurred, denoting a steady increase in soluble solids of the fruit and decrease in the sirup. Of major interest, however, was the rapid approach to the equilibrium value of 1.0 when the berries were stored at 30° F. At this temperature, equilibrium was attained within eight days, and it was clear that thawing temperatures were necessary for the soluble solids of the fruit to become equal to that of the sirup. A ratio of four parts of fruit to one part of dry sugar was used in these samples.

Guadagni, Nimmo and Jansen (12) made a study of retail packages of frozen red raspberries and found that soluble solids of samples held at 20° F., or lower, change very little with storage time. At 25° F., however, the solids content of the raspberries gradually increased while the sirup solids gradually decreased; hence, the soluble solids ratio increases very slowly. When the samples were stored at 30° F., an equilibrium value of 1.0 was obtained in a matter of one to two weeks. A soluble solids ratio of 1.0 is obtained only under complete thawing conditions, and therefore serves as an excellent thaw index.

Thawing Method. Perry and Cruess (20) reported that sliced strawberries of a well-known brand, when thawed on a screen, gave 32.5 percent soluble solids in the sirup and 16.6 percent in the fruit after rinsing and drying with a towel. Sugar penetration had not been very

marked. When thawed in the package and allowed to stand one hour, the sirup showed 30.7 percent soluble solids and the fruit 17.4 percent. At two hours the values were 29.8 and 21.3 percent; at five hours, 29.6 and 22.0 percent; and at 22 hours, 29.8 and 23.9 percent, respectively. The berries had been packed with dry sugar.

Strawberries of the same lot were sliced, covered with sirup, and frozen at once as a check sample. After storage and thawing the sirup was 34.7 percent soluble solids and the fruit 14.0 percent; only 0.5 percent above their natural soluble solids content.

Denaturation of the cell's protein is believed to be the cause of juice loss from a frozen fruit during the thawing process, according to Woodruff (31). This has not been substantiated by recent studies.

Proposed Federal Standards

The Federal Register (7) reported a notice of a proposal to be made part of the Federal Food, Drug, and Cosmetic Act. Part of this proposal had to do with definitions, standards of identity, and fill of container. These, in part, stated that if a frozen fruit in household-size containers has more than five parts or less than four parts by weight of fruit ingredient to one part by weight of dry packing medium, it is reasonable and in the interest of consumers to specify that the name of such frozen fruit include the proportions of fruit ingredient and dry packing medium.

The general industry practice now is to use dry sugar as the packing medium for sliced strawberries. It is reasonable, and in the

interest of consumers, that if a liquid packing medium is used with sliced strawberries, the density of such liquid packing medium not be less than 60° Brix.

It also stated that a reasonable maximum weight of put-in liquid packing medium for sliced strawberries be 25 percent of the combined weight of fruit ingredient and liquid packing medium. A figure of 30 percent was given for red raspberries. A reasonable minimum weight of put-in liquid packing medium for a frozen fruit was given as 15 percent of the combined weight of fruit ingredient and liquid packing medium.

MATERIALS AND METHODS

Raw Material

Strawberries. The Premier variety of strawberry was picked on June 6, 1955, and transported from Keeler, Michigan, to Michigan State University. The berries were placed in a 34° F. room overnight and processed the next morning.

The Northwest variety of strawberry was picked on June 22, 1956, near Corvallis, Oregon. The berries were placed in a 33° F. room overnight at Oregon State College and processed the next morning.

Raspberries. The Taylor variety of red raspberry was picked on July 29, 1954, and transported from Kewadin (Traverse City area), Michigan, to Michigan State University. The berries were placed in a 34° F. room overnight and processed the next morning.

The Willamette variety of red raspberry was picked on July 6, 1956, and transported from Stayton, Oregon, to Oregon State College. The berries were placed in a 33° F. room overnight and processed the next morning.

Sample Processing

The Michigan berries were processed in the Food Technology pilot plant of the Department of Horticulture at Michigan State University. The berries in Oregon were processed in the pilot plant of the Department of Food Technology at Oregon State College.

One hallock was selected at random from each flat in the 34° F. room, and the berries from about fifteen hallocks were blended in a

sink of water. After gently washing and removing blemished and immature berries, they were placed in stainless steel draining pans.

The strawberries were sliced in a mechanical slicer which had revolving blades three-eighths of an inch apart. The sliced strawberries and whole raspberries were then packaged by using different size containers and different amounts and strengths of packing media. The controls had no packing medium; the other samples had dry sugar, water, or sirup as packing media. The amounts of dry sugar and sirup used approximately represent the minimum and maximum levels as given in the Federal Register (7).

The dry sugar packs had 17 percent dry sugar (a ratio of five parts of berries to one part of dry sugar by weight) in one series and 20 percent dry sugar (a ratio of four parts of berries to one part of dry sugar by weight) in the other series.

In one series the water and sirup packs of sliced strawberries had 17 percent packing medium, based on the combined weight of berries and packing medium. The other series had 25 percent packing medium. Red raspberries had 17 percent and 29 percent packing medium, respectively.

Three types of sirups were used for each product. The 50° Brix sirup contained 50 parts sucrose and 50 parts water by weight. The 60° Brix sirup contained 60 parts sucrose and 40 parts water by weight. The third sirup used was labeled corn sirup. It was prepared by replacing 25 percent of the sucrose solids with corn sirup (Puritose #40). The exact strengths of the sirups used as packing media are shown in the respective data tables.

Strawberries in Michigan and raspberries in Oregon were packaged in 211 X 400 (No. 1 picnic) and 307 X 409 (No. 2) "F" enameled cans. Marathon pint heat sealing bags in Marathon pint cartons (about 400 X 310 X 200) were also used. These containers contained seven and one-half, fifteen, and twelve ounces of berries, respectively.

Strawberries in Oregon and raspberries in Michigan were packaged only in the 211 X 400 "F" enameled cans and the Marathon heat sealing bags in Marathon pint cartons.

The packs using liquid packing medium were packaged by weighing into the container the berries and the liquid and sealing the containers. The dry sugar packs were packaged by weighing the berries and dry sugar into separate containers and then pouring them both at the same time into a third container. In Oregon the sliced strawberry dry sugar pack was prepared by mixing the correct weighed amount of berries and sugar into a pan. After standing for about ten minutes, they were filled into the containers and sealed.

The containers in Michigan were frozen in a plate-freezer at -20° F. and placed in 0° F. storage, while in Oregon the samples were frozen in an air-blast freezer at -15° F. and placed in 0° F. storage. The samples were held at 0° F. storage for five to six months with the exception of the Michigan frozen sliced strawberries; these were held five to six weeks. However, this should not influence the comparative results (10) (12) (13) (28).

A sufficient number of samples were packed of each series to give six replicates, plus two extras for "test runs", leakers, errors, etc.

This amounted to approximately one thousand containers of frozen sliced strawberries and red raspberries.

Sample Analysis

Thawing Methods. A rectangular tank, measuring two feet by two feet by two feet, and equipped with a steam heating coil, was used for the water thawing procedure. The containers were placed on a one-inch mesh wire screen six inches below the top of the tank and were totally submerged in water during the period of thawing. They were separated by a series of crosswires, so there was at least one inch of free water circulating about each container. The water was agitated by a propeller-type stirrer with a rated speed of 1725 R.P.M. The water temperature was maintained at 68° F.

Cabinets built for the ripening of peaches were used to thaw the series of air-thaw samples in Michigan. Circulating among the containers placed in the cabinets was a draft of 68° F. air. The containers were spaced so that there was adequate air movement among the samples.

Containers were thawed until the center of each container was approximately 68° F. The length of thawing time was determined by making a few "test runs." Periodically, the actual sample was checked to determine if the desired center temperature was being obtained.

Frozen sliced strawberries at 0° F. with seven and one-half, twelve and fifteen ounces of berries were thawed in moving 68° F. water for two and one-half, two and three-fourths, and three and one-half hours, respectively; and in moving 68° F. air for eight and one-half,

nine, and twelve hours, respectively. Frozen red raspberries at 0° F. with seven and one-half and twelve ounces of berries were thawed in moving 68° F. water for two and two and one-half hours, respectively; and in moving 68° F. air for seven and one-half, and eight hours, respectively.

A series of strawberries in Michigan were given additional thaw-time. The time for these strawberries was extended for two and four additional hours.

<u>Drained</u> <u>Weight</u> <u>Determination</u>. A package containing thawed berries was emptied evenly on a circular screen of eight-mesh wire. The liquid was caught in a pan. After draining exactly two minutes the drained berries were weighed to the nearest one-eighth (0.13) of an ounce. This weight, less the weight of the screen, was recorded as the drained weight for that particular sample. When observing the calculated percentage drained weight (in-going berry weight basis), it would be well to remember that each 0.13 of an ounce of seven and one-half, twelve, and fifteen ounces of berries represents a difference of 1.7, 1.1, and 0.9 percent, respectively.

<u>Soluble</u> <u>Solids</u> <u>Determination</u>. The percent soluble solids was determined by an Abbe refractometer. This determination was made on three parts of each sample: (1) the drained liquid, (2) the liquid obtained after blending the drained berries in a Waring blender for two minutes, and (3) the mixture which resulted from an additional two minutes blending of the Waring blender of the drained liquid and the blended drained berries.

Statistical Analyses.

Standard deviation (SD) and least significance difference (LSD) were determined. The designs and methods of Li (18) furnished helpful guidance.

RESULTS AND DISCUSSION

It is a well-known fact that the variety of the product, the degree of maturity, the cultural influences, the weather conditions, and the processing, freezing, and thawing procedures are extremely important factors involved in obtaining any data on biological material. Nevertheless, the data so obtained are comparable and can indicate trends. It must be remembered in viewing the results of this study that these data are based upon only one common commercial variety of strawberry and one common commercial variety of red raspberry from each of the two states represented, namely Michigan and Oregon. It must also be remembered that these data represent means for only one year in each state.

The results of this experiment are presented in the form of tables. Each datum in these tables represents the average of six replicate samples. The tables are designed to aid in the interpretation of the data with respect to effects of certain packing factors on frozen sliced strawberries and frozen red raspberries used in this experiment. Tables have been organized for each of the products studied to show drained weights of the thawed berries and to show the soluble solids of the thawed product, the thawed drained berries, and the thawed drained liquid. These results are expressed in terms most commonly found in the literature, such as drained weights being reported in ounces and percentages, calculated by comparing the drained weight to the in-going berry weight and to the net weight, and soluble solids being reported as percentage.

Changes in the drained weights and the soluble solids occur during and after thawing of frozen products. These changes are due to leakage of juice through tissues injured by freezing and/or mechanical injury and to the diffusion action of the packing medium. Selective permeability is destroyed by the killing action of freezing temperatures, and the tissues become osmotically indifferent so that a loss or gain of soluble solids as well as water occurs during and after thawing. Mechanical injury, such as the slicing of strawberries, will also affect diffusion.

Additional data were obtained in Michigan with respect to the effect of thawing frozen sliced strawberries and red raspberries by various methods. One series was thawed by means of moving water and another by means of moving air. Still another series of frozen sliced strawberries was thawed by an extended thaw-time in moving water. The data compiled as a result of these studies are found in their respective tables.

Effect of Strength and Amount of Packing Media

The purpose of this series is to show the effect of strength and amount of packing media upon the drained weights and the soluble solids of thawed sliced strawberries and red raspberries.

Drained Weights. The author has noticed that in many published articles the method of percentage determination is not stated clearly. Hence, this paragraph of explanation is felt to be necessary in order to insure clear understanding of the data. The drained weights found

in the tables which pertain to this phase of the experiment (Tables 1, 2, 3, and 4) are not only expressed as ounces but also as percentage of net weight and as percentage of in-going berry weight.

The frozen sliced strawberries and red raspberries packed without any packing medium, both in Michigan and Oregon, had average drained weight ratios of approximately 67 percent and 77 percent, respectively. From these figures it can be noted that the drained weights for the sliced strawberries was approximately 10 percent less than that of the red raspberries.

The sliced strawberries and red raspberries packed in sirup and dry sugar media gave significantly higher drained weights than those packed in a water medium.

There was no significant difference between the 50° Brix packs and the 60° Brix packs for either the sliced strawberries or the red raspberries.

The dry sugar (100° Brix) packs were not as consistent and ranged from similar to lower drained weights than those packed in a water medium. Notations made at the actual determination time indicated that in many instances undissolved sugar remained on the drained berries. This fact may be partially responsible for the variation; therefore, the data from this particular experiment are not conclusive. However, other work done by the author on frozen sliced strawberries has shown that the change in drained weight is primarily due to the loss of juice from the berries.

TABLE 1.

EFFECT OF STRENGTH AND AMOUNT OF PACKING MEDIA ON THE DRAINED WEIGHT OF SLICED STRAWBERRIES

Michigan							Oregon						
Packing Medium		Drained Weight				Headspace	Packing Medium		Drained Weight				Headspace
° Brix	%[a]	Oz.		%[b]	%[c]	in 16th in.	° Brix	%	Oz.		%[b]	%[c]	in 16th in.
Put-in Weight 7.5 oz.													
-	0	5.13[d]	[e]	68.4	68.4	21.3	-	0	5.21[d]	.19[e]	69.5	69.5	21.0
0	17	5.27	.09	70.3	58.6	12.5	0	17	5.65	.22	75.3	62.8	11.0
	25	5.13	.18	68.4	51.3	7.0		25	5.69	.21	75.9	56.9	6.0
50.2	17	5.67	.20	75.6	63.0	12.5	50.7	17	5.61	.14	74.8	62.3	14.5
	25	5.94	.13	79.2	56.7	8.8		25	5.79	.10	77.2	57.9	11.0
60.0	17	5.94	.10	79.2	66.0	13.3	60.7	17	5.73	.27	76.4	63.7	15.0
	25	5.73	.09	76.4	57.3	10.0		25	5.88	.25	78.4	58.8	10.0
100	17	5.38	.20	71.7	59.8	15.5	100	17	5.92	.15	78.9	65.8	16.0
	20	5.11	.18	68.7	54.5	14.4		20	5.96	.22	79.5	63.5	14.0
Average	Low	5.57		74.3	61.9				5.73		76.4	63.7	
Values	High	5.48		73.1	55.0				5.83		77.7	59.3	
No significant difference between packing treatments.							No significant difference between packing treatments.						
Put-in Weight 15 oz.													
-	0	9.57	.23	63.8	63.8	20.0	-	0	10.19	.63	67.9	67.9	20.3
0	17	9.38	.38	62.5	52.1	9.3	0	17	10.63	.08	70.9	59.1	10.7
	25	9.15	.23	61.0	45.8	4.0		25	10.67	.15	71.1	53.4	4.0
50.2	17	10.69	.43	71.3	49.4	11.0	50.7	17	11.00	.31	73.4	61.1	12.0
	25	9.82	.23	65.4	49.1	6.2		25	11.23	.29	74.9	56.2	7.0
60.0	17	10.11	.21	67.4	56.2	12.0	60.7	17	10.90	.31	72.7	60.6	13.0
	25	10.09	.44	67.3	50.5	9.1		25	11.38	.22	75.9	56.9	7.5
100	17	10.19	.21	67.9	56.6	14.0	100	17	11.67	.15	77.8	64.8	14.0
	20	9.86	.16	65.7	52.6	11.7		20	11.65	.37	77.7	62.1	13.3
Average	Low	10.09		67.3	53.6				11.05		73.7	61.4	
Values	High	9.73		64.9	49.5				11.23		74.9	57.2	
LSD between		5%	.18				LSD between						
packing treatments		1%	.24				packing treatment		5%	.15			

(a) Percent of total weight. (b) Percent of in-going berry weight. (c) Percent on total net weight basis. (e) Each datum represents the average of six replicates. (e) Standard deviation.

Table 2.
EFFECT OF STRENGTH AND AMOUNT OF PACKING MEDIA
ON THE DRAINED WEIGHT OF SLICED STRAWBERRIES
PACKED WITH 12 OUNCES OF BERRIES

Packing Medium		Drained Weight			
° Brix	%[a]	Oz.		%[b]	%[c]
		Michigan			
-	0	8.27[d]	.31[e]	68.9	68.9
0	17	8.44	.25	70.3	58.7
	25	7.38	.25	61.5	46.1
50.2	17	8.42	.20	70.2	58.6
	25	8.40	.24	70.0	52.5
60.0	17	9.04	.19	75.2	62.9
	25	7.96	.19	66.3	49.8
100	17	8.44	.20	70.3	58.2
	20	8.50	.26	70.9	56.7
Average	Low	8.59		71.6	59.6
Values	High	8.06		67.2	51.3

LSD between packing treatments: 5% .13; 1% .18

(a) Percent of total net weight.
(b) Percent calculated on in-going berry weight basis.
(c) Percent calculated on net weight basis.
(d) Each datum represents the average of six replicates.
(e) Standard deviation.

Table 3.

EFFECT OF STRENGTH AND AMOUNT OF PACKING MEDIA ON THE DRAINED WEIGHT OF RED RASPBERRIES

Michigan							Oregon						
Packing Medium		Drained Weight				Headspace	Packing Medium		Drained Weight				Headspace
° Brix	%[a]	Oz.		%[b]	%[c]	in 16th in.	° Brix	%[a]	Oz.		%[b]	%[c]	in 16th in.
Put-in Weight 7.5 oz.													
-	0	5.75[d]	.08[e]	76.6	76.7	23.3	-	0	5.77[d]	.09[e]	76.9	76.9	21.3
0	17	6.09	.11	80.0	67.3	14.0	0	17	5.94	.10	79.2	66.0	13.0
	29	6.36	.05	84.8	60.6	6.3		29	6.38	.16	85.1	60.8	5.3
50.4	17	6.27	.05	83.6	69.7	-	51.1	17	6.40	.20	85.3	71.1	14.5
	29	6.84	.10	91.2	65.1	-		29	6.69	.17	89.2	63.7	8.5
60.4	17	6.46	.10	86.1	71.8	16.0	60.8	17	6.48	.21	86.4	72.0	15.0
	29	7.00	.08	93.3	66.7	9.2		29	6.63	.14	88.4	63.1	9.3
100	17	6.48	.09	86.4	72.0	16.0	100	17	6.69	.22	89.2	74.3	16.0
	20	6.69	.10	89.2	71.3	15.5		20	6.75	.45	90.0	72.0	16.0
Average	Low	6.32		84.3	70.2				6.38		85.1	70.9	
Values	High	6.72		89.6	65.9				6.61		88.1	64.9	
LSD between packing treatments: 5% .05; 1% .07							LSD between packing treatments: 5% .21						
Put-in Weight 12 oz.													
-	0	9.36	.12	78.0	78.0	-	-	0	9.32	.17	77.7	77.7	-
0	17	9.78	.12	81.5	67.4	-	0	17	9.69	.13	80.8	66.8	-
	29	9.98	.14	83.2	58.7	-		29	9.94	.17	82.8	58.5	-
50.4	17	9.73	.37	81.8	67.1	-	51.1	17	10.27	.14	85.6	70.8	-
	29	10.34	.07	86.2	60.8	-		29	10.65	.17	88.8	62.6	-
60.4	17	10.15	.14	84.6	70.0	-	60.8	17	10.40	.23	86.7	71.7	--
	29	10.53	.12	87.8	61.9	-		29	10.69	.13	89.1	62.9	-
100	17	9.96	.22	83.0	68.7	-	100	17	10.42	.54	86.8	71.9	-
	20	10.07	.31	83.9	67.1	-		20	10.77	.36	89.8	71.8	-
Average	Low	9.91		82.6	68.3				10.20		85.0	70.3	
Values	High	10.23		85.3	62.1				10.51		87.6	64.0	
LSD between packing treatments: 5% .12; 1% .17							LSD between packing treatments: 5% .13; 1% .18						

(a) Percent of total net weight. (b) Percent of in-going berry weight.
(c) Percent on total net weight basis. (d) Each datum represents average of six replicates.
(e) Standard deviation.

Table 4.
EFFECT OF STRENGTH AND AMOUNT OF PACKING MEDIA
ON THE DRAINED WEIGHT OF RED RASPBERRIES
PACKED WITH 15 OUNCES OF BERRIES

Packing Medium		Drained Weight				Headspace
° Brix	%[a]	Oz.		%[b]	%[c]	in 16th in.
		Oregon				
-	0	11.13[d]	.19[e]	74.2	74.2	21.3
0	17	12.04	.28	80.3	66.9	10.7
	29	11.94	.15	79.6	56.9	2.7
51.1	17	12.25	.14	81.7	68.1	12.3
	29	12.79	.26	85.3	60.9	5.5
60.8	17	12.59	.45	83.9	69.9	13.0
	29	13.06	.22	87.1	62.2	5.3
100	17	12.34	.90	82.3	68.6	20.0
	20	12.77	.30	85.1	68.1	14.9
Average Values	Low	12.31		82.1	68.4	
	High	12.64		84.3	62.0	

LSD between packing treatments: 5% .16; 1% .22

(a) Percent of total net weight.
(b) Percent calculated on in-going berry weight basis.
(c) Percent calculated on net weight basis.
(d) Each datum represents the average of six replicates.
(e) Standard deviation.

With the exception of Michigan strawberries, the highest drained weights were obtained when the maximum amounts of packing medium were used when calculated as percentage of in-going berry weight. However, when expressed as percentage of total net weight, lower values were obtained for the maximum amounts of packing medium than for the minimum amounts of packing medium; for the strawberries 13 and 17 percent less, respectively, and for raspberries 14 and 23 percent less, respectively, for the minimum and maximum amounts of packing medium.

These data indicate the definite importance of knowing how percentage drained weights are calculated before comparing them with other percentages reported in the literature, whether on net weight basis or on in-going berry weight basis.

In the statistical analyses, the strawberry data proved to be rather inconsistent. In the smallest containers (7.5 ounces) the amount of packing medium had no significant effect on the drained weight. The two larger containers (12 ounces and 15 ounces) showed a significant difference at the 5 percent and 1 percent levels and indicated that the maximum amount of packing media gave the highest drained weights with the exception of Michigan strawberries. This exception was probably due to variation in the fresh fruit.

The red raspberry data was consistent in all cases and indicated that the larger amounts of packing media gave higher drained weights at the 5 percent and 1 percent levels.

<u>Soluble Solids</u>. The fresh strawberries used in Michigan for this experiment averaged 6.9 percent soluble solids, and those used

in Oregon averaged 10.5 percent. The soluble solids content of the fresh red raspberries averaged 10.5 and 9.2 percent for Michigan and Oregon, respectively. The national average soluble solids values given for strawberries and red raspberries are 8.0 and 10.5 percent, respectively (19).

The soluble solids of a mixture depends upon the soluble solids of the berries and the sugar or sirup which is added. The effect of the initial soluble solids content is reflected in the final soluble solids reading (Tables 5 and 6). It can also be seen that the soluble solids content of the blended mixture is not significantly different from that calculated from the in-going value, which indicates that the method used for determining these values is quite reliable.

By using a sugar balance method as in Tables 7, 8, 9, and 10, an indication was given of the sugar absorption by the berries. Comparing this data to that of the liquid we arrive at an estimate of the possible error involved by comparing the two methods of calculation. This figure appears on the tables as the root-mean-square of discrepancies and is used as the measure of the difference between two methods. The results indicate that the methods used are reliable.

The soluble solids of both the drained fruit and liquid reflect the amount of sugar added and the ratio of fruit to the packing medium. Using the sugar balance method (Tables 7, 8, 9, and 10) it can be seen that in the lots packed without packing media and the lots packed with water a loss of soluble solids occurs. In the sirup packs, there is a slight absorption of sugar, while in the dry sugar packs there is

Table 5.

EFFECT OF STRENGTH AND AMOUNT OF PACKING MEDIA AND OF SIZE OF CONTAINER ON THE SOLUBLE SOLIDS OF BLENDED SLICED STRAWBERRIES

Michigan

Packing Medium		7.5 oz. berries			12 oz. berries			15 oz. berries		
° Brix	%[a]	Determined S.S. %		Calculated[b] S.S. %	Determined S.S. %		Calculated[b] S.S. %	Determined S.S. %		Calculated[b] S.S. %
-	0	6.4[c]	.12[d]	-	6.3[c]	.38[d]	-	6.9[c]	.10[d]	-
0	17	5.3	.17	5.3	5.0	.24	5.3	5.5	.23	5.8
	25	4.8	.18	4.8	4.4	.16	4.7	5.0	.24	5.2
50.2	17	14.8	.68	13.7	14.3	.19	13.6	14.0	.20	14.1
	25	17.3	.26	17.4	18.1	.08	17.3	17.8	.33	17.7
60	17	14.7	.54	15.3	16.0	.26	15.3	16.5	.35	15.8
	25	20.6	.90	19.8	21.0	.29	19.7	20.8	.34	20.2
100	17	22.0	.68	22.0	23.0	.77	22.5	22.2	.18	22.4
	20	23.9	1.54	25.1	25.1	.64	25.0	26.2	.59	25.5

Table 5--continued.

Packing Medium		7.5 oz. berries			12 oz. berries		15 oz. berries		
° Brix	%[a]	Determined S.S. %		Calculated[b] S.S. %	Determined S.S. %	Calculated[b] S.S. %	Determined S.S. %		Calculated[b] S.S. %
					Oregon				
-	0	10.6	.55	-	-	-	10.5	.33	-
0	17	8.6	.36	8.8	-	-	8.7	.08	8.8
	25	7.2	.23	8.0	--	-	7.3	.21	7.9
50.7	17	17.5	.27	17.3	-	-	17.6	.20	17.2
	25	21.2	.44	20.6	-	-	20.9	.11	20.6
60.7	17	19.5	.50	19.0	-	-	19.1	.21	18.9
	25	22.5	1.82	23.1	-	-	23.0	.25	23.0
100	17	24.7	.84	25.5	-	-	24.5	.39	25.4
	20	26.2	1.15	28.5	-	-	28.0	1.45	28.4
Average Values	Low	15.9		15.9			16.0		16.1
	High	18.0		18.4			18.6		18.6

(a) Percent of total net weight.
(b) Weight of sugar added plus weight of sugar in berries divided by total weight.
(c) Each datum represents the average of six replicates.
(d) Standard deviation.

Table 6.
EFFECT OF STRENGTH AND AMOUNT OF PACKING MEDIA AND OF SIZE OF CONTAINER ON SOLUBLE SOLIDS OF BLENDED RED RASPBERRIES

Packing Medium		7.5 oz. berries			12 oz. berries			15 oz. berries	
° Brix	%[a]	Determined S.S. %		Calculated[b] S.S. %	Determined S.S. %		Calculated[b] S.S. %	Determined S.S. %	Calculated[b] S.S. %
					Michigan				
-	0	10.5[c]	.26[d]	-	10.5[c]	.35[d]	-	-	-
0	17	8.7	.43	8.8	8.8	.24	8.7	-	-
	29	7.9	.11	7.5	7.2	.05	7.4	-	-
50.4	17	18.0	.04	17.2	18.0	.42	17.4	-	-
	29	23.1	.37	21.9	22.6	.79	22.2	-	-
60.4	17	19.5	.22	18.8	19.6	.74	19.1	-	-
	29	25.4	.38	24.8	26.0	.21	25.2	-	-
100	17	24.5	.50	25.4	25.4	.43	25.9	-	-
	20	27.3	.68	28.4	27.1	.26	28.4	-	-

Table 6--continued.

Packing Medium		7.5 oz. berries			12 oz. berries			15 oz. berries		
		Determined S.S. %		Calculated[b] S.S. %	Determined S.S. %		Calculated[b] S.S. %	Determined S.S. %		Calculated[b] S.S. %
° Brix	%[a]									
					Oregon					
-	0	8.8	.66	-	9.2	.39	-	8.8[c]	.57[d]	-
0	17	6.9	.33	7.3	7.2	.34	7.6	7.5	.30	7.3
	29	6.1	.20	6.3	6.0	.14	6.5	5.8	.30	6.3
51.1	17	16.3	.23	15.9	17.1	.22	16.4	16.2	.22	15.9
	29	21.7	.34	20.9	22.0	.17	21.5	21.3	.12	20.9
60.8	17	18.2	.33	17.5	18.8	.49	18.1	18.1	.31	17.5
	29	23.9	.58	23.7	25.1	.18	24.4	24.3	.41	23.7
100	17	23.6	.46	24.0	24.7	.26	24.9	24.5	.77	24.0
	20	25.1	3.44	27.1	26.9	.37	27.4	27.1	.57	27.0
Average Values	Low	17.0		16.9	17.5		17.3	16.6		16.2
	High	20.1		20.1	20.4		20.4	19.6		19.5

(a) Percent of total net weight.
(b) Weight of sugar added plus weight of sugar in berries divided by total weight.
(c) Each datum represents the average of six replicates.
(d) Standard deviation.

Table 7.
EFFECT OF STRENGTH AND MINIMUM AMOUNT OF PACKING MEDIA ON THE SOLUBLE SOLIDS OF DRAINED SLICED STRAWBERRIES AND LIQUID AND SUGAR ABSORPTION

Packing Medium ° Brix	Soluble Solids				Sugar loss or gain			
	Fruit %		Liquid %		Fruit oz.	Liquid oz.	Fruit %[a]	Liquid %[a]
				Michigan				
				Put-in Weight 7.5 ounces berries				
-	6.2[b]	.15[c]	6.0[b]	.05[c]	-.16	.14	-2.2	1.9
0	5.4	.21	4.9	.09	-.20	.20	-2.6	2.7
50.2	10.1	.43	20.6	1.18	.09	-.07	1.2	-0.9
60.0	9.6	.45	22.3	.86	.09	-.22	1.2	-2.9
100	16.8	.45	29.3	1.59	.42	-.44	5.7	-5.9
				Put-in Weight 12 ounces berries				
-	6.2	.59	6.0	.20	-.24	.22	-2.0	1.9
0	5.6	.27	4.3	.12	-.28	.26	-2.4	2.1
50.2	10.1	.53	19.3	.87	.09	-.06	.08	- .05
60.0	10.2	.20	24.7	.50	.17	-.12	1.4	-1.0
100	17.0	1.48	29.3	1.17	.68	-.72	5.7	-6.0
				Put-in Weight 15 ounces berries				
-	6.8	.31	6.3	.32	-.38	.34	-2.6	2.3
0	6.0	.00	4.7	.15	-.47	.41	-3.2	2.7
50.2	11.1	.50	17.9	.70	.15	-.20	1.0	-1.3
60.0	11.4	.44	21.4	.72	.12	-.11	0.8	-0.8
100	16.4	.66	29.2	.74	.64	-.72	4.2	-4.8
				Oregon				
				Put-in Weight 7.5 ounces berries				
-	12.5	.50	9.5	.50	-.14	.22	-1.9	2.9
0	9.8	.42	6.4	.39	-.24	.21	-3.2	2.9
50.7	14.2	.23	21.3	.33	0	-.04	0	-0.5
60.7	15.6	.40	24.9	.82	.10	-.10	1.3	-1.3
100	20.2	.68	31.9	.54	.40	-.52	5.4	-6.9
				Put-in Weight 15 ounces berries				
-	10.8	.23	9.7	.18	-.47	.47	-3.2	3.1
0	9.8	.16	7.0	.16	-.53	.52	-3.6	3.4
50.7	15.1	.27	21.7	1.51	.09	.0	0.6	.0
60.7	16.0	.26	22.9	.77	.17	-.20	1.1	-1.3
100	20.9	.61	30.2	.95	.86	-1.09	5.8	-7.3

Root-mean-square of discrepancies .07 ounces

(a) Percent calculated on fresh weight basis.
(b) Each datum represents the average of six replicates.
(c) Standard deviation.

Table 8.

EFFECT OF STRENGTH AND MAXIMUM AMOUNT OF PACKING MEDIA ON THE SOLUBLE SOLIDS OF DRAINED SLICED STRAWBERRIES AND LIQUID AND SUGAR ABSORPTION

Packing Medium	Soluble Solids				Sugar loss or gain			
	Fruit		Liquid		Fruit	Liquid	Fruit	Liquid
° Brix	%		%		oz.	oz.	%[a]	%[a]
			Michigan					
			Put-in Weight 7.5 ounces berries					
-	6.2[b]	.15[c]	6.0[b]	.05[c]	-.16	.14	-2.2	1.9
0	5.3	.24	4.0	.12	-.21	.29	-2.8	3.4
50.2	10.1	.08	26.8	.71	.12	-.17	1.6	-2.2
60	10.5	.61	31.2	.74	.12	-.17	1.6	-2.2
100	17.6	1.09	31.1	1.96	.42	-.55	5.6	-7.3
			Put-in Weight 12 ounces berries					
-	6.2	.59	6.0	.20	-.24	.22	-2.0	1.9
0	5.0	.04	4.0	.05	-.39	.35	-3.2	2.9
50.2	10.9	.41	22.9	1.14	.16	-.27	1.3	-2.2
60	11.0	.34	27.2	.99	.12	-.21	1.0	-1.8
100	17.1	1.42	33.8	1.07	.70	-.80	5.8	-6.7
			Put-in Weight 15 ounces berries					
-	6.8	.31	6.3	.32	-.38	.34	-2.6	2.3
0	5.4	.21	4.2	.10	-.54	.46	-3.6	3.0
50.2	11.8	.31	22.6	.70	.12	-.21	0.8	-1.4
60.0	13.3	.31	26.8	1.28	.31	-.34	2.1	-2.3
100	18.6	1.34	32.9	1.01	.80	-.83	5.3	-5.5
			Oregon					
			Put-in Weight 7.5 ounces berries					
-	12.5	.50	9.5	.50	-.14	.22	-1.9	2.9
0	8.4	.21	5.4	.36	-.30	.23	-4.0	3.1
50.7	16.1	.43	27.0	.24	.14	-.13	1.8	-1.8
60.7	18.2	.19	30.2	.67	.28	-.27	3.7	-3.7
100	20.6	1.03	34.9	1.07	.43	-.68	5.8	-9.1
			Put-in Weight 15 ounces berries					
-	10.8	.23	9.7	.18	-.47	.47	-3.2	3.1
0	8.2	.29	6.1	.11	-.70	.57	-4.7	3.8
50.7	16.6	.34	25.5	.46	.29	-.30	1.9	-2.0
60.7	17.6	.42	29.5	.63	.43	-.49	2.9	-3.3
100	22.5	.94	36.0	1.81	1.05	-1.19	7.0	-8.0

Root-mean-square of discrepancies .09 ounces

(a) Percent calculated on fresh weight basis.
(b) Each datum represents the average of six replicates.
(c) Standard deviation.

Table 9.

EFFECT OF STRENGTH AND MINIMUM AMOUNT OF PACKING MEDIA ON THE SOLUBLE SOLIDS OF DRAINED RED RASPBERRIES AND LIQUID AND SUGAR ABSORPTION

Packing Medium ° Brix	Soluble Solids				Sugar loss or gain			
	Fruit %		Liquid %		Fruit oz.	Liquid oz.	Fruit %[a]	Liquid %[a]
				Michigan				
			Put-in Weight 7.5 ounces berries					
-	11.0[b]	.04[c]	9.5[b]	.32[c]	-.16	.17	-2.1	2.2
0	10.2	.08	7.2	.43	-.17	.22	-2.3	2.9
50.4	14.5	.28	24.2	.66	.12	-.10	1.6	-1.3
60.4	15.7	.42	27.5	.49	.23	-.21	3.0	-2.8
100	19.0	.63	41.0	1.42	.44	-.47	5.9	-6.2
			Put-in Weight 12 ounces berries					
-	11.1	.15	8.8	.20	-.22	.23	-1.8	1.9
0	10.1	.10	5.4	.12	-.27	.26	-2.3	2.1
50.4	14.2	.04	25.0	1.21	.12	-.07	1.0	-0.6
60.4	15.1	.28	29.1	.97	.27	-.24	2.3	-2.0
100	17.3	.92	42.4	.70	.46	-.58	3.9	-4.8
				Oregon				
			Put-in Weight 7.5 ounces berries					
-	8.9	.70	7.2	.46	-.15	.13	-2.0	1.7
0	8.4	.35	3.9	.20	-.16	.12	-2.2	1.6
51.1	12.0	.30	26.3	.84	.11	-.08	1.4	-1.1
60.8	12.3	.37	31.1	.83	.14	-.13	1.8	-1.7
100	16.7	.63	42.6	2.21	.46	-.52	6.1	-6.9
			Put-in Weight 12 ounces berries					
-	9.4	.40	7.7	.36	-.23	.21	-1.9	1.7
0	8.4	.24	4.4	.31	-.29	.21	-2.4	1.8
51.1	12.5	.38	26.1	.57	.18	-.17	1.5	-1.5
60.8	13.2	.22	30.9	1.36	.27	-.25	2.2	-2.1
100	17.4	.47	41.5	2.77	.71	-.81	5.9	-6.7
			Put-in Weight 15 ounces berries					
-	9.1	.59	7.5	.49	-.31	.29	-2.1	1.9
0	8.8	.28	4.8	.28	-.26	.29	-1.7	1.9
51.1	12.0	.29	23.7	.67	.15	-.17	1.0	-1.1
60.8	12.8	.59	29.3	1.40	.29	-.24	2.0	-1.6
100	16.6	.98	41.8	1.94	.73	-.63	4.9	-4.2

Root-mean-square of discrepancies .05 ounces

(a) Percent calculated on fresh weight basis.
(b) Each datum represents the average of six replicates.
(c) Standard deviation.

Table 10.

EFFECT OF STRENGTH AND MAXIMUM AMOUNT OF PACKING MEDIA ON THE SOLUBLE SOLIDS OF DRAINED RED RASPBERRIES AND LIQUID AND SUGAR ABSORPTION

Packing Medium ° Brix	Soluble Solids Fruit %		Soluble Solids Liquid %		Sugar loss or gain Fruit oz.	Sugar loss or gain Liquid oz.	Sugar loss or gain Fruit %[a]	Sugar loss or gain Liquid %[a]
			Michigan					
			Put-in Weight 7.5 ounces berries					
-	11.0[b]	.04[c]	9.5[b]	.32[c]	-.16	.17	-2.1	2.2
0	9.5	.34	5.6	.34	-.18	.23	-2.5	3.1
50.4	18.0	.59	30.9	.33	.44	-.38	5.9	-5.1
60.4	19.0	.59	37.6	.78	.54	-.47	7.2	-6.6
100	20.5	.62	46.7	2.58	.58	-.62	7.8	-8.3
			Put-in Weight 12 ounces berries					
-	11.1	.15	8.8	.20	-.22	.23	-1.8	1.9
0	9.5	.23	4.3	.30	-.31	.30	-2.6	2.5
50.4	16.1	.20	32.0	2.52	.41	-.39	3.4	-3.2
60.4	17.6	.55	38.5	.70	.59	-.53	4.9	-4.4
100	18.9	1.37	43.9	3.66	.64	-.84	5.4	-7.0
			Oregon					
			Put-in Weight 7.5 ounces berries					
-	8.9	.70	7.2	.46	-.15	.13	-2.0	1.7
0	8.2	.26	3.1	.08	-.14	.13	-1.8	1.7
51.1	13.9	1.86	34.6	.47	.27	-.22	3.6	-2.9
60.8	13.7	.62	39.1	1.05	.25	-.31	3.3	-4.2
100	19.3	1.13	46.9	1.68	.64	-.65	8.6	-8.6
			Put-in Weight 12 ounces berries					
-	9.4	.40	7.7	.36	-.23	.21	-1.9	1.7
0	7.9	.12	3.7	.26	-.32	.26	-2.7	2.2
51.1	14.0	.18	33.9	.32	.39	-.40	3.2	-3.4
60.8	15.1	.31	40.3	.86	.51	-.50	4.3	-4.1
100	19.7	1.66	43.6	2.27	1.02	-1.16	8.5	-9.6
			Put-in Weight 15 ounces berries					
-	9.1	.59	7.5	.49	-.31	.29	-2.1	1.9
0	7.4	.40	3.8	.28	-.44	.34	-2.9	2.3
51.1	13.7	.25	32.4	.55	.43	-.41	2.9	-2.7
60.8	14.7	.44	38.6	1.17	.60	-.58	4.0	-3.9
100	17.9	1.08	45.3	1.32	.97	-1.04	6.4	-6.9

Root-mean-square of discrepancies .06 ounces

(a) Percent calculated on fresh weight basis.
(b) Each datum represents the average of six replicates.
(c) Standard deviation.

considerably more. However, this may not be a true absorption. In many cases during the actual determination of the dry sugar packs, it was noted that undissolved sugar remained on the surface of the drained berries. Therefore, on the basis of these results, it is presumptuous to state that there is any direct relationship between true sugar absorption and drained weight.

Dixon's sign test was used on the data for sliced strawberries (Table 11). Chi-square was found to be equal to 6.25, which is greater than 3.84, the 5 percent point of Chi-square distribution with one degree of freedom. The conclusion is that Oregon strawberries, with the higher soluble solids content, absorbed significantly more sugar than the Michigan strawberries.

Dixon's sign test was also used on the red raspberry data (Table 12). In this instance the Chi-square value was found to be equal to 2.25, which is less than 3.84, the 5 percent point of Chi-square distribution with one degree of freedom. Therefore, the absorption difference between the Michigan and Oregon red raspberries is not significant.

Effect of Size of Container.

The purpose of this series is to indicate the effect the size of container has upon the drained weights and the soluble solids of these particular thawed sliced strawberries and red raspberries. Both of the products were packed into different size containers before being processed.

Table 11.
SUGAR ABSORPTION OF SLICED STRAWBERRIES

Packing Medium ° Brix	Berries oz.	Packing Medium %	Sugar Gain Michigan oz.	Sugar Gain Oregon oz.	Sign
50	7.5	17	0.093	0.002	+
		25	0.120	0.137	-
	15.0	17	0.152	0.086	+
		25	0.124	0.289	-
60	7.5	17	0.090	0.099	-
		25	0.122	0.275	-
	15.0	17	0.118	0.169	-
		25	0.307	0.428	-
60 (corn sirup)	7.5	17	0.090	0.093	-
		25	0.095	0.259	-
	15.0	17	0.098	0.105	-
		25	0.284	0.435	-
100	7.5	17	0.424	0.401	+
		20	0.419	0.433	-
	15.0	17	0.636	0.864	-
		20	0.799	1.046	-
Average Values		Low	0.213	0.227	
		High	0.284	0.413	

By Dixon's sign test, Chi-square equals 6.25 with 1 d.f.

Table 12.
SUGAR ABSORPTION OF RED RASPBERRIES

Packing Medium ° Brix	Berries oz.	Packing Medium %	Sugar Gain Michigan oz.	Sugar Gain Oregon oz.	Sign
50	7.5	17	0.121	0.108	+
		29	0.443	0.270	+
	12.0	17	0.122	0.180	-
		29	0.405	0.387	+
60	7.5	17	0.226	0.137	+
		29	0.542	0.248	+
	12.0	17	0.273	0.269	+
		29	0.593	0.510	+
61 (corn sirup)	7.5	17	0.220	0.117	+
		29	0.534	0.323	+
	12.0	17	0.254	0.218	+
		29	0.607	0.456	+
100	7.5	17	0.443	0.457	-
		20	0.583	0.643	-
	12.0	17	0.463	0.709	-
		20	0.643	1.018	-
Average Values		Low	0.265	0.274	
		High	0.544	0.482	

By Dixon's sign test, Chi-square equals 2.25 with 1 d.f.

Drained Weight. Drained weight cannot be expressed as ounces when a comparison is to be made between the drained weight of berries packed in different size containers. Therefore, in this experiment, drained weights are expressed as percentage based on net weight and on in-going berry weight (Tables 1, 2, 3, and 4).

The drained weights for sliced strawberries which were packed in both Michigan and Oregon in different size containers without any packing medium were approximately 10 percent less than that of red raspberries. The drained weights were approximately 67 percent and 77 percent for sliced strawberries and red raspberries, respectively.

The drained weight ratios decreased as the size of the container increased (Tables 1, 2, 3, and 4). The large containers probably gave lower drained weights because of the greater weight of the berries and the resulting crushing effect and/or the longer thaw-time that was necessary for the center of the container to reach the temperature of the defrosting medium (68° F.). The berries and the packing medium to the exterior of the container were thawed and remained at 68° F. while the heat penetrated the remainder of the container. This, of course, was a longer period of time than was necessary for the smaller sized containers.

Soluble Solids. The soluble solids of a mixture depends upon the soluble solids of the berries and the sugar or sirup which is added. The effect of the initial soluble solids content is reflected in the final soluble solids content of the pack (Tables 5 and 6). It can also be seen that the soluble solids content of the blended

mixture is not significantly different from that calculated from the in-going value, which indicates that the method used for determining these values is quite reliable.

The soluble solids of the thawed products indicate the fluctuations which could be expected due to differences in container sizes (Tables 7, 8, 9, and 10). In general, the larger containers gave slightly higher soluble solids in the thawed product. This was also true for the drained berries, but the opposite was true for the drained liquid. The trend was much more generally noticed in analyzing the sliced strawberries, which was probably due to the fact that their cut flesh surfaces are more sensitive to water and sugar diffusion.

Greater fluctuation in data can be expected with the smaller containers. In a smaller amount, as in the 7.5 ounce container, one berry or slice of berry added to the pack or one berry or slice of berry withheld from the pack has a greater influence on the end result.

Effect of Partial Replacement of Sugar Sirup with Corn Sirup

The purpose of this series is to determine what effect partial replacement of sugar sirup with corn sirup would have upon the drained weights and soluble solids of the thawed sliced strawberries and red raspberries. The berries were packaged in the usual manner except for the sirup packing medium. A 60 percent sirup was used in which 25 percent of the sucrose solids were replaced by corn sirup solids. This type of packing medium has become quite common in

commercial packs.

Drained Weights. The sliced strawberry data indicated no significant difference in the drained weights of either the Michigan or the Oregon packs between the sucrose sirup pack and the sucrose corn sirup pack.(Table 13). The red raspberry data showed similar results (Table 14).

Soluble Solids. There were no significant differences in the average means of the soluble solids of the sliced strawberry and red raspberry samples used in this series (Tables 15 and 16). Therefore, the data in this particular series are comparable.

There were no significant differences in the average soluble solids of the thawed drained sliced strawberries or red raspberries and drained liquid between the sucrose sirup pack and the sucrose corn sirup pack (Tables 17 and 18).

Effect of Thawing by Means of Moving Water and Moving Air

The primary influencing factor when thawing by different media is the rate of heat exchange between the container and the surrounding medium. Water is a much better heat conductor than air. This is again proven in this experiment because of the much longer length of time required for air thawing than for water thawing.

Drained Weights. The drained weights of the water-thawed sliced strawberries were significantly higher than those thawed by moving air (Table 19). There was no significant difference in the drained weights of the red raspberries between thawing treatments (Table 20).

Table 13.
EFFECT OF PARTIAL REPLACEMENT OF SUGAR SIRUP WITH CORN SIRUP ON THE DRAINED WEIGHTS OF SLICED STRAWBERRIES

Packing Medium %[a]	Packing Medium oz.	Berries oz.	Sugar Sirup[b] Drained Weight oz.		Corn Sirup[cd] Drained Weight oz.	
			Michigan			
17	1.5	7.5	5.94[e]	.10[f]	5.63[e]	.14[f]
25	2.5	7.5	5.73	.09	5.42	.10
17	2.4	12.0	9.04	.19	8.71	.25
25	4.0	12.0	7.96	.19	8.19	.29
17	3.0	15.0	10.11	.21	9.77	.31
25	5.0	15.0	10.09	.44	9.92	.27
Average			8.15		7.94	
			Oregon			
17	1.5	7.5	5.73	.27	5.73	.21
25	2.5	7.5	5.88	.25	6.02	.12
17	3.0	15.0	10.90	.31	10.98	.17
25	5.0	15.0	11.38	.22	11.42	.20
Average			8.47		8.54	
General average			8.36		8.29	

No significant difference between sirup treatments.

(a) Percent of total net weight.
(b) The sugar sirup was 60.0° B and 60.7° B for Michigan and Oregon, respectively.
(c) 75 percent sugar sirup and 25 percent corn sirup by weight.
(d) The corn sirup was 59.9° B and 60.4° B for Michigan and Oregon, respectively.
(e) Each datum represents the average of six replicates.
(f) Standard deviation.

Table 14.

EFFECT OF PARTIAL REPLACEMENT OF SUGAR SIRUP WITH CORN SIRUP ON THE DRAINED WEIGHTS OF RED RASPBERRIES

Packing Medium %[a]	Packing Medium oz.	Berries oz.	Sugar Sirup[b] Drained Weight oz.		Corn Sirup[cd] Drained Weight oz.	
			Michigan			
17	1.5	7.5	6.46[e]	.10[f]	6.38[e]	.16[f]
29	3.0	7.5	7.00	.08	6.96	.13
17	2.5	12.0	10.15	.14	10.09	.10
29	5.0	12.0	10.53	.12	10.61	.09
Average			8.54		8.51	
			Oregon			
17	1.5	7.5	6.48	.21	6.32	.17
29	3.0	7.5	6.63	.14	6.78	.15
17	2.5	12.0	10.40	.23	10.25	.11
29	3.0	12.0	10.69	.13	10.54	.21
17	3.0	15.0	12.59	.45	12.88	.11
29	6.0	15.0	13.06	.22	13.11	.14
Average			9.98		9.98	
General Average			9.26		9.26	

No significant difference between sirup treatments.

(a) Percent of total net weight.
(b) The sugar sirup was 60.4° B and 60.8° B for Michigan and Oregon, respectively.
(c) 75 percent sugar sirup and 25 percent corn sirup by weight.
(d) The corn sirup was 61.1° B and 61.0° B for Michigan and Oregon, respectively.
(e) Each datum represents the average of six replicates.
(f) Standard deviation.

Table 15.
EFFECT OF PARTIAL REPLACEMENT OF SUGAR SIRUP WITH CORN SIRUP ON THE SOLUBLE SOLIDS OF SLICED STRAWBERRIES

Packing Medium %[a]	Packing Medium oz.	Berries oz.	Sugar Sirup[b] Soluble Solids %		Corn Sirup[cd] Soluble Solids %	
			Michigan			
17	1.5	7.5	14.7[e]	.54[f]	16.7[e]	.97[f]
25	2.5	7.5	20.6	.90	20.5	.47
17	2.4	12.0	16.0	.26	16.3	.14
25	4.0	12.0	21.0	.29	20.1	.13
17	3.0	15.0	16.5	.35	16.1	.29
25	5.0	15.0	20.8	.33	20.6	.24
Average			18.3		18.4	
			Oregon			
17	1.5	7.5	19.5	.50	19.3	.43
25	2.5	7.5	22.5	1.82	23.2	.35
17	3.0	15.0	19.1	.21	18.2	.04
25	5.0	15.0	23.0	.25	22.9	.25
Average			21.0		20.9	
General average			19.7		19.7	

No significant difference between sirup treatments.

(a) **Percent of total net weight.**
(b) **The sugar sirup was 60.0° B and 60.7° B for Michigan and Oregon, respectively.**
(c) **75 percent sugar sirup and 25 percent corn sirup by weight.**
(d) **The corn sirup was 59.9° B and 60.4° B for Michigan and Oregon, respectively.**
(e) **Each datum represents the average of six replicates.**
(f) **Standard deviation.**

Table 16.
EFFECT OF PARTIAL REPLACEMENT OF SUGAR SIRUP WITH CORN SIRUP ON THE SOLUBLE SOLIDS OF RED RASPBERRIES

Packing Medium %[a]	Packing Medium oz.	Berries oz.	Sugar Sirup[b] Soluble Solids %		Corn Sirup[cd] Soluble Solids %	
			Michigan			
17	1.5	7.5	19.5[e]	.22[f]	19.8[e]	.34[f]
29	3.0	7.5	25.4	.38	25.5	.47
17	2.5	12.0	19.6	.74	19.5	.21
29	5.0	12.0	26.0	.21	26.0	.12
Average			22.6		22.7	
			Oregon			
17	1.5	7.5	18.2	.33	18.1	.55
29	3.0	7.5	23.9	.58	24.6	.24
17	2.5	12.0	18.8	.49	18.6	.25
29	5.0	12.0	25.1	.18	24.7	.17
17	3.0	15.0	18.1	.31	18.4	.55
29	6.0	15.0	24.3	.41	24.2	.19
Average			21.4		21.4	
General average			22.0		22.1	

No significant difference between sirup treatments.

(a) Percent of total net weight.
(b) The sugar sirup was 60.4° B and 60.8° B for Michigan and Oregon, respectively.
(c) 75 percent sugar sirup and 25 percent corn sirup by weight.
(d) The corn sirup was 61.1° B and 61.0° B for Michigan and Oregon, respectively.
(e) Each datum represents the average of six replicates.
(f) Standard deviation.

Table 17.

EFFECT OF PARTIAL REPLACEMENT OF SUGAR SIRUP WITH CORN SIRUP ON THE SOLUBLE SOLIDS OF DRAINED SLICED STRAWBERRIES AND LIQUID

			Drained Berries				Drained Liquid			
			Sugar[b]		Corn[cd]		Sugar[b]		Corn[cd]	
Packing %[a]	Medium oz.	Berries oz.	Soluble %	Solids	Soluble %	Solids	Soluble %	Solids	Soluble %	Solids
					Michigan					
17	1.5	7.5	9.6[e]	.45[f]	10.2[e]	.28[f]	22.3[e]	.86[f]	25.2[e]	.74[f]
25	2.5	7.5	10.5	.61	10.6	.64	31.2	.74	29.8	.80
17	2.4	12.0	10.2	.20	10.6	.51	24.7	.50	23.3	.94
25	4.0	12.0	11.0	.34	10.9	.39	27.2	.99	28.2	.56
17	3.0	15.0	11.4	.44	11.6	.36	21.4	.72	20.7	.72
25	5.0	15.0	13.3	.31	13.3	.50	26.8	1.28	27.2	.54
Average			11.0		11.2		25.6		25.7	
					Oregon					
17	1.5	7.5	15.6	.40	15.5	.40	24.9	.82	24.5	.38
25	2.5	7.5	18.2	.19	17.5	.51	30.2	.67	31.1	.62
17	3.0	15.0	16.0	.26	15.3	.26	22.9	.77	22.2	.27
25	5.0	15.0	17.6	.42	17.6	.69	29.5	.63	29.3	.63
Average			16.9		16.5		26.9		26.8	
General Average			13.3		13.3		26.1		26.2	

No significant difference between sirup treatments.

(a) Percent of total net weight.
(b) The sugar sirup was 60.0° B and 60.7° B for Michigan and Oregon, respectively.
(c) 75 percent sugar sirup and 25 corn sirup by weight.
(d) The corn sirup was 59.9° B and 60.4° B for Michigan and Oregon, respectively.
(e) Each datum represents the average of six replicates.
(f) Standard deviation.

Table 18.

EFFECT OF PARTIAL REPLACEMENT OF SUGAR SIRUP WITH CORN SIRUP ON THE SOLUBLE SOLIDS OF DRAINED RED RASPBERRIES AND LIQUID

Packing %[a]	Medium oz.	Berries oz.	Soluble Solids, berries Sugar[b] %		Corn[cd] %		Soluble Solids, liquid Sugar[b] %		Corn[cd] %	
					Michigan					
17	1.5	7.5	15.7[e]	.42[f]	15.8[e]	.67[f]	27.5[e]	.49[f]	27.7[e]	.96[f]
29	3.0	7.5	19.0	.59	19.0	.30	37.6	.78	38.1	.84
17	2.5	12.0	15.1	.28	15.0	.14	29.1	.97	28.7	.23
29	5.0	12.0	17.6	.55	17.6	.41	38.5	.70	38.7	.72
Average			16.9		16.9		33.2		33.2	
					Oregon					
17	1.5	7.5	12.3	.37	12.3	.39	31.1	.83	30.7	1.53
29	3.0	7.5	13.7	.62	14.5	.33	39.1	1.05	41.1	1.14
17	2.5	12.0	13.2	.22	12.9	.27	30.9	1.36	30.2	.87
29	5.0	12.0	15.1	.31	14.8	.57	40.3	.86	39.6	.88
17	3.0	15.0	12.8	.59	12.9	.43	29.3	1.40	29.9	1.19
29	6.0	15.0	14.7	.44	14.2	.30	38.6	1.17	38.8	.52
Average			13.6		13.6		34.9		35.1	
General average			14.9		14.9		34.2		34.4	

No significant difference between sirup treatments.

(a) Percent of total net weight.
(b) The sugar sirup was 60.4° B and 60.8° B for Michigan and Oregon, respectively.
(c) 75 percent sugar sirup and 25 percent corn sirup by weight.
(d) The corn sirup was 61.1° B and 61.0° B for Michigan and Oregon, respectively.
(e) Each datum represents the average of six replicates.
(f) Standard deviation.

Table 19.
EFFECT OF THAWING BY MEANS OF MOVING WATER AND MOVING AIR AT 68° F. ON THE DRAINED WEIGHTS OF SLICED STRAWBERRIES

Packing Medium			Berries	Water Thaw Drained Weight		Air Thaw Drained Weight	
° Brix	%[a]	oz.	oz.	oz.		oz.	
0	17	1.5	7.5	5.27[b]	.09[c]	5.07[b]	.07[c]
	25	2.5	7.5	5.13	.18	4.77	.17
	17	2.4	12.0	8.44	.25	8.13	.43
	25	4.0	12.0	7.38	.25	6.92	.13
	17	3.0	15.0	9.38	.38	8.86	.24
	25	5.0	15.0	9.15	.23	8.69	.34
Average				7.46		7.07	
50.2	17	1.5	7.5	5.67	.20	5.54	.10
	25	2.5	7.5	5.94	.13	5.65	.12
	17	2.4	12.0	8.42	.20	8.32	.15
	25	4.0	12.0	8.40	.24	8.40	.22
	17	3.0	15.0	10.69	.43	9.56	.40
	25	5.0	15.0	9.82	.23	8.98	.15
Average				8.16		7.74	
60	17	1.5	7.5	5.94	.10	5.73	.12
	25	2.5	7.5	5.73	.09	5.69	.23
	17	2.4	12.0	9.04	.19	8.71	.23
	25	4.0	12.0	7.96	.19	8.09	.27
	17	3.0	15.0	10.11	.21	9.48	.09
	25	5.0	15.0	10.09	.44	9.77	.18
Average				8.15		7.91	
100	17	1.5	7.5	5.38	.20	4.92	.10
	20	1.9	7.5	5.11	.18	4.82	.13
	17	2.4	12.0	8.44	.20	8.23	.12
	20	3.0	12.0	8.50	.26	8.44	.22
	17	3.0	15.0	10.19	.21	9.52	.12
	20	3.8	15.0	9.86	.16	9.54	.13
Average				7.91		7.58	
General Average				7.92		7.58	

LSD between thawing treatments 5% .05; 1% .07

(a) Percent of total net weight.
(b) Each datum represents the average of six replicates.
(c) Standard deviation.

Table 20.
EFFECT OF THAWING BY MEANS OF MOVING WATER AND MOVING AIR AT 68° F. ON DRAINED WEIGHT OF RED RASPBERRIES

Packing Medium			Berries	Water Thaw Drained Weight		Air Thaw Drained Weight	
° Brix	%[a]	oz.	oz.	oz.		oz.	
0	17	1.5	7.5	6.06[b]	.11[c]	6.21[b]	.06[c]
	29	3.0	7.5	6.36	.05	6.48	.05
	17	2.5	12.0	9.78	.12	9.52	.05
	29	5.0	12.0	9.98	.14	9.82	.13
Average				8.05		8.01	
50.4	17	1.5	7.5	6.27	.05	6.50	.14
	29	3.0	7.5	6.84	.10	6.88	.11
	17	2.5	12.0	9.73	.37	9.55	.10
	29	5.0	12.0	10.34	.07	10.34	.13
Average				8.30		8.32	
60.4	17	1.5	7.5	6.46	.10	6.61	.12
	29	3.0	7.5	7.00	.08	6.92	.10
	17	2.5	12.0	10.15	.14	9.67	.15
	29	5.0	12.0	10.53	.12	10.34	.13
Average				8.54		8.39	
100	17	1.5	7.5	6.48	.09	6.44	.13
	20	1.9	7.5	6.69	.10	6.54	.10
	17	2.5	12.0	9.96	.22	9.32	.13
	20	3.0	12.0	10.07	.31	9.36	.14
Average				8.30		7.92	
General Average				8.29		8.16	

No significant difference between thawing treatments.

(a) Percent of total net weight.
(b) Each datum represents the average of six replicates.
(c) Standard deviation.

The greater effect shown by the sliced strawberries was probably due to the greater loss of juice from the cut flesh of the sliced berries because of the longer length of time necessary for the berries to thaw by moving air.

Soluble Solids. The soluble solids of the mixture of sliced strawberries and sweetener used in this series showed no significant difference between thawing methods (Table 21). Therefore, the data are comparable.

The soluble solids of the water-thawed drained sliced strawberries which were packed in sirup and dry sugar were significantly lower than those which were air-thawed (Table 22). The opposite was true for the drained liquid. In this case, the water-thawed samples had the highest soluble solids except for the water packs, which showed no difference. Thawing by means of moving air was a longer process than the water thawing procedure and probably this factor was the reason for the difference in soluble solids. When air-thawing, the berries and the sirup were in contact for a longer period of time; hence, there was a greater possibility of approaching equilibrium.

The sliced strawberries which were packed in a water medium showed an opposite effect from the sirup and dry sugar packs. The soluble solids of the water-thawed drained sliced strawberries which were packed in water were significantly higher than the air-thawed samples. These packs showed this opposite effect because the water did not contain any soluble solids to diffuse into the berries. There was no difference in soluble solids of the drained liquid as

Table 21.
EFFECT OF THAWING BY MEANS OF MOVING WATER AND MOVING AIR AT 68° F. ON THE SOLUBLE SOLIDS OF SLICED STRAWBERRIES

Packing Medium ° Brix	%[a]	oz.	Berries oz.	Water Thaw Soluble Solids %		Air Thaw Soluble Solids %	
9	17	1.5	7.5	5.3[b]	.17[c]	5.1[b]	.14[c]
	25	2.5	7.5	4.8	.18	4.8	.26
	17	2.4	12.0	5.0	.24	5.4	.27
	25	4.0	12.0	4.4	.16	4.6	.15
	17	3.0	15.0	5.5	.23	5.2	.10
	25	5.0	15.0	5.0	.04	4.7	.22
Average				5.0		5.0	
50.2	17	1.5	7.5	14.8	.68	14.0	.11
	25	2.5	7.5	17.3	.26	17.2	.28
	17	2.4	12.0	14.3	.19	14.9	.34
	25	4.0	12.0	18.1	.08	18.1	.13
	17	3.0	15.0	14.0	.20	14.5	.29
	25	5.0	15.0	17.8	.33	18.3	.22
Average				16.1		16.2	
60	17	1.5	7.5	14.7	.54	15.0	.55
	25	2.5	7.5	20.6	.90	19.5	.49
	17	2.4	12.0	16.0	.26	16.6	.36
	25	4.0	12.0	21.0	.29	21.1	.52
	17	3.0	15.0	16.5	.35	16.5	.43
	25	5.0	15.0	20.8	.34	21.0	.17
Average				18.3		18.3	
100	17	1.5	7.5	22.0	.68	22.3	.75
	20	1.9	7.5	23.9	1.54	24.5	.94
	17	2.4	12.0	23.0	.77	23.9	.33
	20	3.0	12.0	25.1	.64	25.4	.69
	17	3.0	15.0	22.2	.18	22.8	.50
	20	3.8	15.0	26.2	.59	25.9	.31
Average				23.7		24.1	
General Average				15.8		15.9	

No significant difference between thawing treatments.

(a) Percent of total net weight.
(b) Each datum represents the average of six replicates.
(c) Standard deviation.

Table 22.

EFFECT OF THAWING BY MEANS OF MOVING WATER AND MOVING AIR AT 68° F. ON THE SOLUBLE SOLIDS OF DRAINED SLICED STRAWBERRIES AND LIQUID

Packing Medium			Berries	Soluble Solids, berries				Soluble Solids, liquid			
				Water		Air		Water		Air	
°Brix	%[a]	oz.	oz.	%		%		%		%	
0	17	1.5	7.5	5.4[b]	.21[c]	5.3[b]	.08[c]	4.9[b]	.09[c]	4.7[b]	.17[c]
	25	2.5	7.5	5.3	.24	5.0	.17	4.0	.12	4.1	.19
	17	2.4	12.0	5.6	.27	5.6	.31	4.3	.12	4.7	.22
	25	4.0	12.0	5.0	.04	4.8	.18	4.0	.05	4.2	.15
	17	3.0	15.0	6.0	.00	5.9	.08	4.7	.15	4.7	.13
	25	5.0	15.0	5.4	.21	5.1	.16	4.2	.10	4.2	.05
Average				5.5		5.3		4.4		4.4	
50.2	17	1.5	7.5	10.1	.43	9.7	.31	20.6	1.18	19.6	1.08
	25	2.5	7.5	10.1	.08	10.0	1.03	26.8	.71	25.8	.59
	17	2.4	12.0	10.1	.53	12.2	.30	19.3	.87	17.3	.12
	25	4.0	12.0	10.9	.41	13.8	.73	22.9	1.14	22.3	.64
	17	3.0	15.0	11.1	.50	11.6	.26	17.9	.70	17.3	.55
	25	5.0	15.0	11.8	.31	12.8	.34	22.6	.70	22.1	.53
Average				10.7		11.7		21.7		20.7	
60	17	1.5	7.5	9.6	.45	10.1	.90	22.3	.86	23.0	1.52
	25	2.5	7.5	10.5	.61	11.0	.53	31.2	.74	29.7	.95
	17	2.4	12.0	10.2	.20	13.4	.29	24.7	.50	20.5	.59
	25	4.0	12.0	11.0	.34	14.3	.64	27.2	.99	24.8	.89
	17	3.0	15.0	11.4	.44	12.7	.12	21.4	.72	20.2	.75
	25	5.0	15.0	13.3	.31	14.3	.50	26.8	1.28	26.3	.73
Average				11.0		12.6		25.6		24.1	
100	17	1.5	7.5	16.8	.45	17.9	1.11	29.3	1.59	26.8	1.15
	20	1.9	7.5	17.6	1.09	18.8	1.39	31.1	1.96	29.4	1.26
	17	2.4	12.0	17.0	1.48	19.4	1.26	29.3	1.17	29.0	.94
	20	3.0	12.0	17.1	1.42	21.4	.71	33.8	1.07	29.9	1.86
	17	3.0	15.0	16.4	.66	18.4	1.00	29.2	.74	27.4	.61
	20	3.8	15.0	18.6	1.34	20.9	.73	32.9	1.01	30.0	.66
Average				17.3		19.5		30.9		28.8	
General Average				11.1		12.3		20.7		19.5	

LSD between thawing treatments: soluble solids, fruit 5% .15
soluble solids, liquid 5% .20; 1% .27

(a) Percent of total net weight.
(b) Each datum represents the average of six replicates.
(c) Standard deviation.

would be expected. This was due to variation in composition of the raw product.

The soluble solids of the mixture of red raspberries and sweetener used in this series showed a significant difference between thawing methods (Table 23). Therefore, it is evident that there was a variation in composition of the raw product. This explains why the soluble solids data were so erratic and inconsistent (Table 24) and is further substantiated by the standard deviations.

These data (Table 24) indicate no significant difference in soluble solids of the drained red raspberries between thawing treatments. The soluble solids of the drained liquid showed a significant difference at the 5 and 1 percent levels.

The drained liquid from red raspberries which were packed in a water medium and thawed by means of moving water gave a significantly lower soluble solids than similar packs which were air-thawed. The soluble solids of the drained liquid from red raspberries which had been packed in sirup and dry sugar and water-thawed were significantly higher than the air-thawed samples.

Effect of Extended Thaw-time in Moving Water

The purpose of this series was to determine what effect extended thaw-time would have upon the drained weights and soluble solids of the thawed sliced strawberries which have been packed in 60° Brix sirup and dry sugar.

Table 23.
EFFECT OF THAWING BY MEANS OF MOVING WATER AND MOVING AIR AT 68° F. ON THE SOLUBLE SOLIDS OF RED RASPBERRIES

Packing Medium			Berries	Water Thaw Soluble Solids		Air Thaw Soluble Solids	
° Brix	%[a]	oz.	oz.	%		%	
0	17	1.5	7.5	10.2[b]	.08[c]	10.1[b]	.22[c]
	29	3.0	7.5	9.5	.34	9.2	.26
	17	2.5	12.0	10.1	.10	10.4	.48
	29	5.0	12.0	9.5	.23	9.5	.37
Average				9.8		9.8	
50.4	17	1.5	7.5	14.5	.28	15.6	.47
	29	3.0	7.5	18.0	.59	18.2	.35
	17	2.5	12.0	14.2	.04	14.4	.35
	29	5.0	12.0	16.1	.20	16.8	.80
Average				15.7		16.3	
60.4	17	1.5	7.5	15.7	.42	16.5	.51
	29	3.0	7.5	19.0	.59	20.1	.54
	17	2.5	12.0	15.1	.28	15.1	.35
	29	5.0	12.0	17.6	.55	18.6	.47
Average				16.9		17.6	
100	17	1.5	7.5	19.0	.63	19.4	.58
	20	1.9	7.5	20.5	.62	18.8	2.33
	17	2.5	12.0	17.3	.92	18.6	.60
	20	3.0	12.0	18.9	1.37	19.5	.75
Average				18.9		19.1	
General Average				15.3		15.7	

LSD between thawing treatments 5% .15; 1% .20.

(a) Percent of total net weight.
(b) Each datum represents the average of six replicates.
(c) Standard deviation.

Table 24.

EFFECT OF THAWING BY MEANS OF MOVING WATER AND MOVING AIR AT 68° F. ON THE SOLUBLE SOLIDS OF DRAINED RED RASPBERRIES AND LIQUID

Packing Medium			Berries	Soluble Solids, berries				Soluble Solids, liquid			
				Water		Air		Water		Air	
° Brix	%[a]	oz.	oz.	%		%		%		%	
0	17	1.5	7.5	8.7[b]	.43[c]	8.8[b]	.23[c]	7.2[b]	.43[c]	7.0[b]	.00[c]
	29	3.0	7.5	7.9	.11	7.5	.20	5.6	.34	5.6	.39
	17	2.5	12.0	8.8	.24	8.9	.53	5.4	.12	6.7	.22
	29	5.0	12.0	7.2	.05	7.4	.29	4.3	.30	5.2	.16
Average				8.2		8.2		5.6		6.1	
50.4	17	1.5	7.5	18.0	.04	17.7	.31	24.2	.66	22.4	.74
	29	3.0	7.5	23.1	.37	22.6	.34	30.9	.33	30.0	.77
	17	2.5	12.0	18.0	.42	17.9	.05	25.0	1.21	23.4	.51
	29	5.0	12.0	22.6	.79	22.7	.92	32.0	2.52	31.4	.69
Average				20.4		20.2		28.0		26.8	
60.4	17	1.5	7.5	19.5	.22	19.9	.49	27.5	.49	26.6	1.08
	29	3.0	7.5	25.4	.38	25.7	.41	37.6	.78	35.2	1.21
	17	2.5	12.0	19.6	.74	19.5	.20	29.1	.97	27.0	1.01
	29	5.0	12.0	26.0	.21	26.2	.12	38.5	.70	37.1	.51
Average				22.6		22.8		33.2		31.5	
100	17	1.5	7.5	24.5	.50	25.4	.80	41.0	1.42	42.1	1.62
	20	1.9	7.5	27.3	.68	27.1	1.45	46.2	2.58	44.3	3.25
	17	2.5	12.0	25.4	.43	25.3	.72	42.4	.70	36.7	1.20
	20	3.0	12.0	27.1	.26	27.2	1.06	43.9	3.66	41.8	1.33
Average				26.1		26.3		43.4		41.2	
General Average				19.3		19.4		27.6		26.4	

LSD between thawing treatments: soluble solids, fruit NSD
soluble solids, liquid 5% .19; 1% .25

(a) Percent of total net weight.
(b) Each datum represents the average of six replicates.
(c) Standard deviation.

Drained Weights. For both packs, the 60° Brix and the dry sugar, the drained weights were significantly lower when the thaw-time was extended two hours. However, the four hour extended thaw-time was not significantly different from the two hour extended thaw-time (Table 25).

Soluble Solids. The soluble solids of the sliced strawberries packed in dry sugar and used in this series showed no significant difference between extended thaw-time treatments (Table 26). However, the sliced strawberries packed in 60° Brix medium showed a significant difference. This difference was probably due to difference in the fresh berries.

The soluble solids of the drained sliced strawberries (Table 27) were not significantly higher at normal thaw-time plus two hours, but were significantly higher at normal thaw-time plus four hours additional thaw-time.

The soluble solids of the drained liquid (Table 28) from the series packed in 60° Brix were not significantly lower at two hours extended thaw-time, but were at the four hour level. The dry sugar packs were significantly lower at the two hour extended thaw-time level.

The literature (10) (12) reported that thawing temperatures are necessary for the soluble solids of the fruit to become equal to that of the sirup. It also reported that the soluble solids ratio could serve as an excellent thaw index. The data obtained as a result of these determinations indicate that if these types of data are to be used for this purpose a definite length of thaw-time must be established.

Table 25.
EFFECT OF EXTENDED THAW TIME
IN MOVING WATER ON THE DRAINED WEIGHTS OF SLICED STRAWBERRIES

Packing Medium ° Brix	%[a]	Berries oz.	Normal Thaw Drained Weight oz.		Thaw plus Two Hours Drained Weight oz.		Thaw plus Four Hours Drained Weight oz.	
60	25	7.5	5.73[b]	.09[c]	5.36[b]	.15[c]	5.57[b]	.13[c]
	29	7.5	5.69	.10	5.36	.12	5.30	.25
	25	12.0	7.96	.19	7.94	.17	7.98	.25
	29	12.0	8.50	.14	7.98	.32	8.21	.49
	25	15.0	10.09	.44	10.06	.25	9.88	.41
	29	15.0	10.34	.37	10.29	.43	10.13	.39
Average			8.05		7.83		7.85	
LSD between extended thaw-time treatments 5% .14; 1% .18								
100	17	7.5	5.38	.20	4.94	.10	4.92	.13
	20	7.5	5.11	.18	4.80	.10	4.86	.12
	17	12.0	8.44	.20	8.23	.18	8.17	.65
	20	12.0	8.50	.26	7.96	.41	8.11	.30
	17	15.0	10.19	.21	9.83	.20	9.54	.20
	20	15.0	9.86	.16	9.50	.35	9.59	.26
Average			7.91		7.54		7.53	
LSD between extended thaw-time treatments 5% .13; 1% .17								

(a) Percent of total net weight.
(b) Each datum represents the average of six replicates.
(c) Standard deviation.

Table 26.

EFFECT OF EXTENDED THAW TIME
IN MOVING WATER ON THE SOLUBLE SOLIDS OF SLICED STRAWBERRIES

Packing Medium		Berries	Normal Thaw Soluble Solids		Thaw plus Two Hours Soluble Solids		Thaw plus Four Hours Soluble Solids	
° Brix	%[a]	oz.	%		%		%	
60	25	7.5	20.6[b]	.90[c]	20.0[b]	.85[c]	19.8[b]	.86[c]
	29	7.5	23.5	.48	22.8	1.06	23.0	.64
	25	12.0	21.0	.29	20.7	.40	20.5	.32
	29	12.0	22.8	.32	22.9	.16	23.2	.20
	25	15.0	20.8	.34	20.0	.34	20.4	.63
	29	15.0	23.0	.28	22.7	.43	22.9	.64
Average			22.0		21.5		21.6	
LSD between extended thaw time treatments 5% .27; 1% .36								
100	17	7.5	22.0	.68	22.5	.49	22.4	1.26
	20	7.5	23.9	1.54	24.9	.50	24.7	1.18
	17	12.0	23.0	.77	23.2	.79	23.2	1.03
	20	12.0	25.1	.64	24.2	.59	25.8	.46
	17	15.0	22.2	.18	22.3	.37	22.3	.25
	20	15.0	26.2	.59	26.0	1.44	25.2	1.06
Average			23.7		23.9		23.9	
No significant difference between extended thaw time treatments.								

(a) Percent of total net weight.
(b) Each datum represents the average of six replicates.
(c) Standard deviation.

Table 27.
EFFECT OF EXTENDED THAW TIME IN MOVING WATER
ON THE SOLUBLE SOLIDS OF DRAINED SLICED STRAWBERRIES

Packing Medium ° Brix	Packing Medium %[a]	Berries oz.	Normal Thaw Soluble Solids %		Thaw plus Two Hours Soluble Solids %		Thaw plus Four Hours Soluble Solids %	
60	25	7.5	10.5[b]	.61[c]	10.9[b]	.55[c]	11.0[b]	.20[c]
	29	7.5	11.2	.65	11.0	.19	12.1	.95
	25	12.0	11.0	.34	11.7	.43	13.0	.60
	29	12.0	11.5	.53	12.4	.35	12.7	.37
	25	15.0	13.3	.31	13.0	.27	13.5	.46
	29	15.0	14.8	.60	13.2	.51	13.7	.71
Average			12.1		12.0		12.7	
LSD between extended thaw time treatments 5% .24; 1% .32								
100	17	7.5	16.8	.45	17.2	.62	17.9	.46
	20	7.5	17.6	1.09	18.2	.29	19.3	1.28
	17	12.0	17.0	1.48	17.1	1.06	18.5	1.18
	20	12.0	17.1	1.42	17.3	.45	20.0	1.39
	17	15.0	16.4	.66	16.8	.84	17.2	.39
	20	15.0	18.6	1.34	18.8	1.03	20.4	1.42
Average			17.3		17.6		18.9	
LSD between extended thaw time treatments 5% .47; 1% .63								

(a) Percent of total net weight.
(b) Each datum represents the average of six replicates.
(c) Standard deviation.

Table 28.

EFFECT OF EXTENDED THAW TIME IN MOVING WATER
ON THE SOLUBLE SOLIDS OF DRAINED LIQUID FROM SLICED STRAWBERRIES

Packing Medium ° Brix	% [a]	Berries oz.	Normal Thaw Soluble Solids %		Thaw plus Two Hours Soluble Solids %		Thaw plus Four Hours Soluble Solids %	
60	25	7.5	31.2 [b]	.74 [c]	29.2 [b]	.65 [c]	29.6 [b]	.99 [c]
	29	7.5	34.1	.54	32.2	.88	31.9	.86
	25	12.0	27.2	.99	28.4	.77	27.7	.75
	29	12.0	31.1	1.87	31.1	1.07	30.7	1.61
	25	15.0	26.8	1.28	26.8	1.32	26.2	.86
	29	15.0	29.8	.39	30.8	.51	30.1	.63
Average			30.0		29.8		29.4	
LSD between extended thaw time treatments 5% .47; 1% .62								
100	17	7.5	29.3	1.59	27.3	1.07	26.6	1.52
	20	7.5	31.1	1.96	31.5	.57	29.9	1.02
	17	12.0	29.3	1.17	29.7	.94	29.1	1.24
	20	12.0	33.8	1.07	30.9	.75	31.6	1.75
	17	15.0	29.2	.74	28.3	.78	27.4	.52
	20	15.0	32.9	1.01	32.3	.77	28.9	1.29
Average			30.9		30.0		28.9	
LSD between extended thaw time treatments 5% .55; 1% .73								

(a) Percent of total net weight.
(b) Each datum represents the average of six replicates.
(c) Standard deviation.

SUMMARY AND CONCLUSIONS

A study was made to provide more scientific information on the effect of certain packing factors on drained weights and soluble solids of frozen sliced strawberries and frozen red raspberries in Michigan and Oregon.

On the basis of data obtained, the following conclusions can be made concerning drained weights:

1. Frozen sliced strawberries and red raspberries packed without packing medium had average drained weight:put-in weight ratios of approximately 67 percent and 77 percent, respectively.

2. Frozen sliced strawberries and frozen red raspberries packed in a water medium gave lower drained weights than those packed in sirup and dry sugar media. There was no difference in drained weights between 50° Brix and 60° Brix packs.

3. With exception of Michigan strawberries, highest drained weights were obtained when maximum amounts of packing medium were used when calculated as percentage of in-going berry weight. When expressed as percentage of total net weight, lower values were obtained for maximum amounts of packing medium.

4. Drained weight ratios decreased as size of container increased.

5. There was no difference in drained weights between sucrose sirup packs and sucrose corn sirup packs.

6. Drained weights of water-thawed sliced strawberries were higher than those thawed by moving air; there was no difference in

drained weights of red raspberries between thawing treatments.

7. Drained weights of thawed sliced strawberries were lower when thaw-time in moving water was extended two hours; no additional decrease occurred at four hours thaw-time.

The following conclusions can be made concerning soluble solids:

1. Oregon frozen sliced strawberries, with higher soluble solids, absorbed more sugar than Michigan strawberries. There was no absorption difference in frozen red raspberries from the two states.

2. A loss in soluble solids occurred when frozen sliced strawberries and frozen red raspberries were packed without packing medium or packed in a water medium. A gain in soluble solids occurred in sirup packs, and an even higher gain occurred in dry sugar packs. However, drained berries from dry sugar packs often had undissolved sugar on their surfaces.

3. Larger containers gave higher soluble solids in thawed product (total blended mixture), in drained berries, and lower soluble solids in drained liquid.

4. There was no difference in soluble solids of thawed drained sliced strawberries and red raspberries and drained liquid between sucrose sirup pack and sucrose corn sirup packs.

5. Soluble solids of air-thawed drained sliced strawberries were higher than those which were water-thawed; correspondingly, the soluble solids of the water-thawed drained liquid of sliced strawberries were higher than those which were air-thawed.

6. There was no difference in soluble solids between drained

red raspberries which were air-thawed and those which were water-thawed; soluble solids of the water-thawed drained liquid of red raspberries were higher than those which were air-thawed.

7. There was no difference in soluble solids of drained sliced strawberries at normal thaw-time plus two hours, but soluble solids were higher at four hours extended thaw-time. Soluble solids of drained liquid were lower at two hours and four hours extended thaw-time levels, respectively.

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